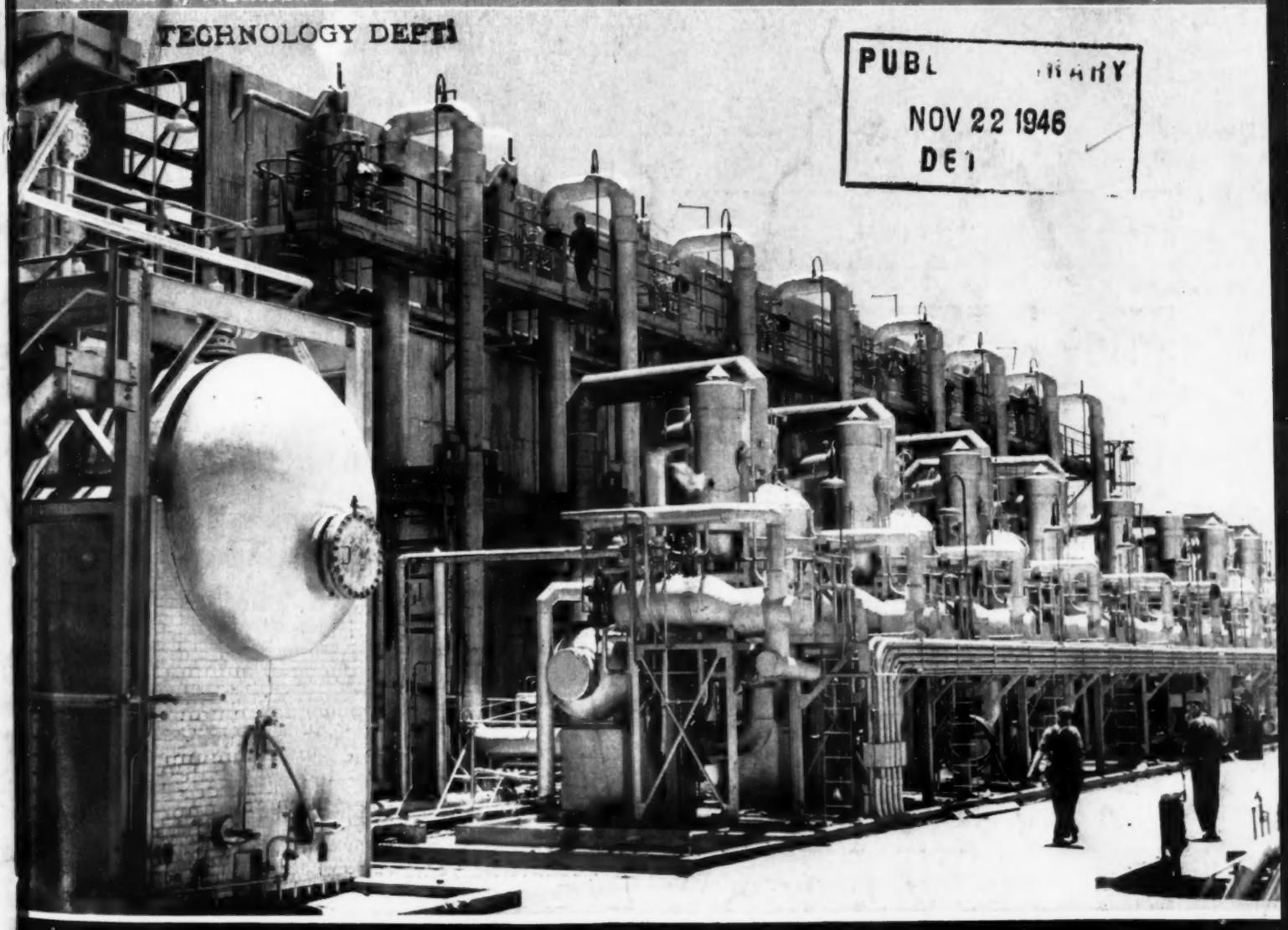
PETROLEUM PROCESSING

VOLUME 1, NUMBER 2 OCTOBER, 1946

TECHNOLOGY DEPT.

PUBL ARY
NOV 22 1946
DET



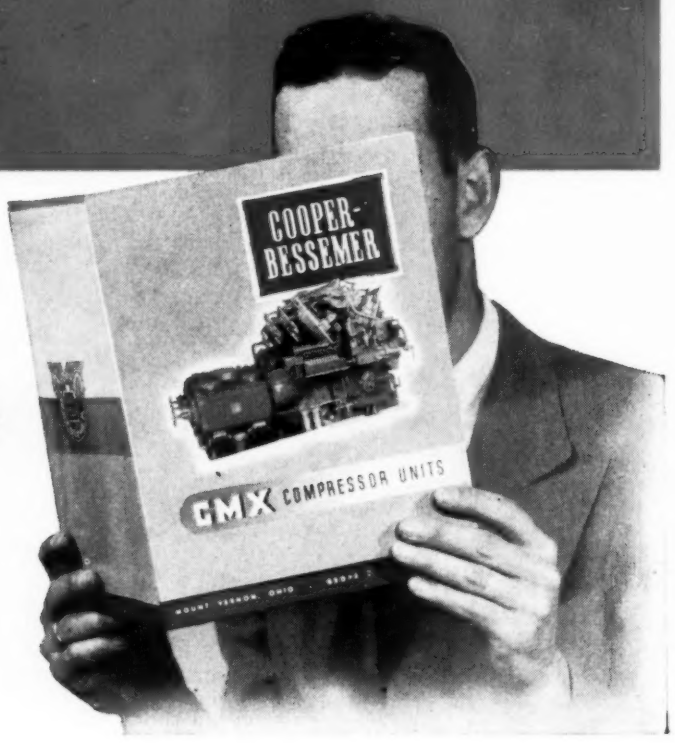
FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

NEW GMX BULLETIN

GIVES YOU THE *Inside Story*

OF COOPER-BESSEMER'S

Latest COMPRESSOR DEVELOPMENT



Instructive

Comprehensive

In this new 20-page bulletin our recently introduced 2-cycle, V-engine-driven, angle-type GMX compressor and its major parts are literally opened for your inspection. You can see and weigh the value of each important feature in relation to any of your compressor requirements from 250 to 625 hp.* Specifications and other data are, of course, included.

Write today for your copy.

* For compressor requirements up to 1000 hp ask for new bulletin No. 337 on the GMV—"big brother" of the new GMX.

The
Cooper-Bessemer
Corporation

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Calif. Seattle, Wash. Houston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles

STAFF

WARREN C. PLATT.....Publisher
V. B. GUTHRIE.....Editor
A. E. KRAFT.....Treasurer
V. A. KOSKINEN.....Advertising Manager
D. P. THORNTON, Jr.....Assistant Editor
WILLIAM F. BLAND.....Engineering Editor

PUBLICATION OFFICE

Cleveland 13, Ohio.....1213 West 3rd St.
CHerry 7672

NEWS BUREAUS

New York 20, N. Y.....50 West 50th St.
Washington 4, D. C.....1034 National Press Bldg.
Chicago 5, Ill.....59 East Van Buren St.
Tulsa 3, Oklahoma.....904 World Bldg.

PETROLEUM PROCESSING

Of Crude Petroleum and Natural Gas
For Fuels, Lubricants and Petrochemicals

REFINERY OPERATION, MAINTENANCE, EQUIPMENT, DESIGN

FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

COMING MEETINGS

October

3-5, Petroleum Division, American Institute of Mining and Metallurgical Engineers, Fall meeting, Galvez Hotel, Galveston.
7-11, 34th National Safety Congress and exposition, sponsored by the National Safety Council, Stevens Hotel, Petroleum Section, Congress Hotel, Chicago.
11th, Western Petroleum Refiners Assn., Regional meeting Washington-Youree Hotel, Shreveport, La.
11th, California Natural Gas Association, 21st Annual meeting, Ambassador Hotel, Los Angeles.
7-12, American Gas Association, Annual meeting, Atlantic City, N. J.
24-25, Petroleum Fuels Division of the American Institute of Mining and Metallurgical Engineers, Ambassador Hotel, Los Angeles.

November

7-8, Society of Automotive Engineers, National Fuels and Lubricants meeting, Mayo Hotel, Tulsa.
11-14, American Petroleum Institute, Annual meeting, Stevens Hotel, Chicago.
17-20, American Institute of Chemical Engineers, Annual meeting, Bellevue-Stratford Hotel, Philadelphia.
18-22, American Society for Metals, Annual Metal Congress and Exposition, Municipal Auditorium, Atlantic City, N. J.
21-22, American Standards Association, Annual meeting, Waldorf-Astoria, New York.

THIS MONTH'S COVER . . .

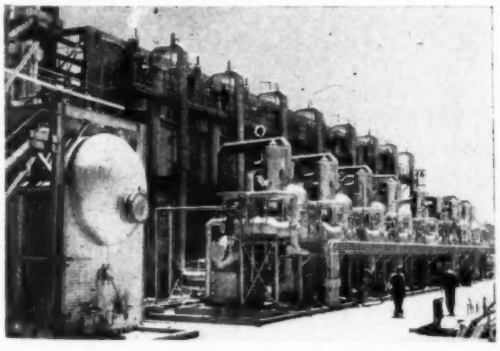


Photo courtesy Standard Oil Co. of Calif.

This battery of eight reactors at the Richmond refinery of Standard Oil Co. of Calif. converts ortho-xylene and air to phthalic anhydride, one of many new petroleum products and processes reported at the recent San Francisco Regional Meeting of the American Institute of Chemical Engineers. Tall vertical piping behind reactors carries phthalic anhydride through heat exchangers and into condenser boxes in back of corrugated wall. Vessel in left foreground is heater of primary still for purifying the crude phthalic anhydride. Details on this and other West Coast processes are reported in this issue of PETROLEUM PROCESSING, page 83

Contents

Volume 1, Number 2 **October, 1946**

Plant Operation

Wastes Reclaimed; Used as Cooling Water 92
Preventing the Fouling of Cooling Waters Reduces Plant's Waste Disposal Costs (Article 10), *by W. B. Hart* ..... 102★
Crude Oil Assays Prove Valuable Working Tool for Refiner's Design Engineers and Plant Operators, *by J. L. Petersen and H. G. Cannon* ..... 113★

Refinery Equipment

Plant Practices for Refinery Superintendents, Foremen ..... 97★
Oil Heating Furnace Produces Steam for Processing Also, New Patents on Equipment ..... 122★
Classroom Plus On-the-Job Training Pays Its Way In Instrument Course, *by D. P. Thornton, Jr.* ..... 136★

Refining Processes

New West Coast Processes Make Chemicals and Improved Lubricants and Waxes, *by William F. Bland* ..... 83★
91 Octane Gasoline Can Be Made by Naphtha Isomerization Process 140
Fractional Distillation (Article 1), *by R. R. White* ..... 151★

Petroleum Research

German Aircraft Oils Were Made by Polymerization of Olefins 126
Partial Oxidation of Ethane Used in German Ethylene Manufacture 135
Improved Techniques for Chemical Refining of Petroleum Products Reported at ACS Meeting ..... 146★

Departments

Tomorrow in Petroleum Technology ..... 94★
Patent Trends in Petroleum Refining, *by Peter J. Gaylor* ..... 111★
New Books for the Oil Man 158
Petroleum Technologists in the Headlines 159
Widening Horizons ..... 160★

★Exclusive in *PETROLEUM PROCESSING*

Published monthly by The National Petroleum Publishing Co., 1213 West 3rd St., Cleveland 13, Ohio. Publication date—first Tuesday of each month. Subscription rate, $3.00 a year in United States and its possessions, $3.50 a year elsewhere. Single issues, 35 cents per copy; back copies more than three months old, 50 cents per copy. Formerly published (prior to September, 1946) as the Technical Section of National Petroleum News, devoted to REFINERY MANAGEMENT and PETROLEUM CHEMICAL TECHNOLOGY and including International Petroleum Technology. Trade mark registered U. S. Patent Office.

Copyright 1946 by The National Petroleum Publishing Co.

Motor transportation makes it possible for thousands of communities to grow in remote sections of the country. Built along the nation's highways, they depend entirely upon trucks, buses, automobiles and airplanes to maintain physical contact with the rest of the world.

Towns are built on gasoline

OVER FIFTY-FOUR thousand communities in the United States are entirely dependent on gasoline transportation—and there is not a town anywhere which does not depend upon it to some degree. And it would be hard to find a man, woman or child—or a business or an industry—that does not benefit each time the cost of automotive transportation is reduced.

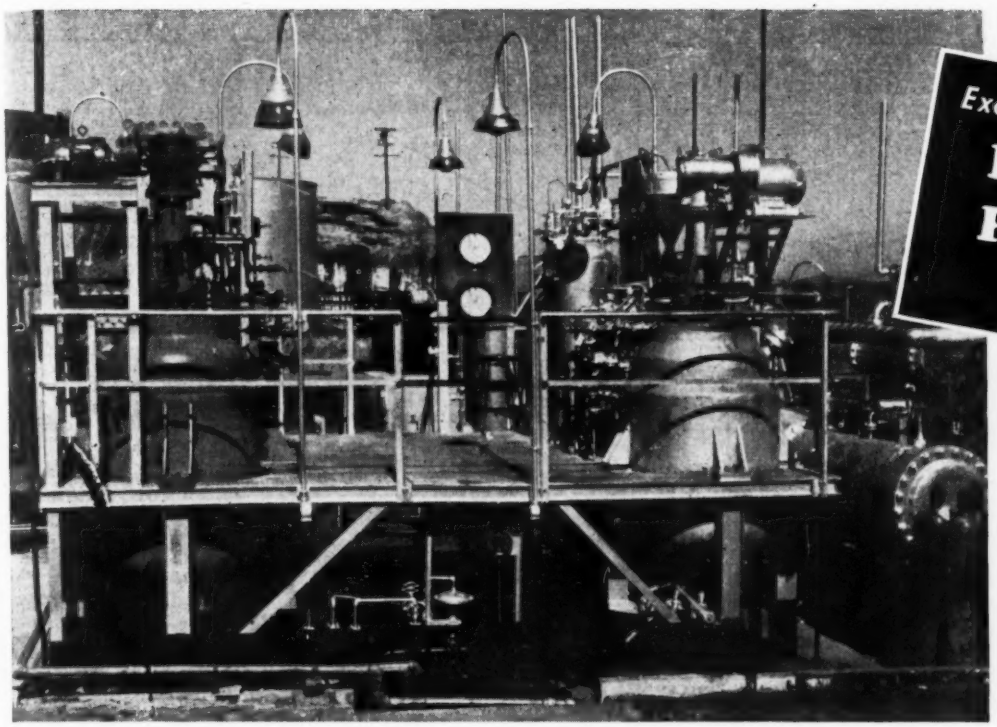
During the past twenty years such reductions have been many. For one thing, gasoline costs less today than it did in 1926. And by producing increasingly *better* gasoline over the years, through improved refining methods and the use of Ethyl antiknock fluid, refiners have paved the way for the development of more powerful engines that provide better transportation at lower cost.

If tomorrow's cars, trucks and buses are to be even more efficient than they are today, they will be made that way by designing engines that can take advantage of the extra power available in improved gasoline. That is why, now, as in the years past, Ethyl's research and service organizations are working in close cooperation both with oil companies who use our product and with automotive companies who strive to keep engine design in pace with gasoline progress. Ethyl Corporation, Chrysler Building, New York 17, N. Y.

More power from every gallon of gasoline through

ETHYL

Research · Service · Products



Exclusive in . . .
PETROLEUM PROCESSING
OCTOBER, 1946

Sulfolanes, a new group of non-corrosive solvents, are made in these steam-heated autoclaves at Shell Chemical Corp.'s Martinez, Calif. plant

New West Coast Processes Make Chemicals And Improved Lubricants and Waxes

Details of Development Work By California Refiners, Much of it Originating During the War and Now Applied to Commercial Operations, Are Disclosed at Regional Meeting of the American Institute of Chemical Engineers

By WILLIAM F. BLAND
Engineering Editor,
Petroleum Processing

New wartime and postwar petroleum products and processes were revealed for the first time to the chemical engineers of this country at the San Francisco Regional Meeting of the American Institute of Chemical Engineers, Aug. 25-28. For the most part these new developments originated in the Pacific Coast refining industry.

Three major western petroleum companies and one eastern one discussed the technical details of laboratory, pilot plant and commercial experiences with some of their most important developments.

Among the products and processes described at the meeting were the following:

Phthalic Anhydride — used in the manufacture of improved paints and varnishes, and now being made for the first time from petroleum and for the first time on the west coast by Standard Oil Co. of Calif., operating a plant at its Richmond refinery for Oronite Chemical Co., its chemical subsidiary.

Sulfolanes — a new group of non-corrosive solvents developed during the war years. Shell Chemical Corp., the chemical subsidiary of Shell Oil Co., has just completed a semi-commercial plant for the manufacture of one of them, dimethylsulfolane, at Martinez, Calif.

High Melting Point Paraffin Waxes—being produced by Union Oil Co. of Calif. at Oleum, Calif., from California crude waxes, using a special Union Oil process employing methyl-ethyl-ketone as solvent.

Allyl Chloride and Allyl Alcohol — used in the manufacture of pharmaceuticals and important thermosetting resins, and now being made from petroleum propylene by a process developed in the Shell laboratories at Emeryville, Calif.

Synthetic Ethyl Alcohol—being made from petroleum ethylene by Standard Oil Co. of New Jersey, Louisiana Division, the first petroleum refinery to produce the material commercially.

Catalytic Desulfurization of Crude—a new process developed by Union Oil Co. of Calif., using cobalt molybdate as catalyst, and now said to be ready for commercial application.

Hydrocarbon Distillation Drying — California Research Corp., a subsidiary

(Standing, left to right) George M. Fekula, R. D. Lee, John E. Walkey, H. Childress, George C. Gester, Jr. (Plant Trips Committee chairman), Charles Schmitz. (Seated, left to right) J. Howard Arnold, F. M. Parker, E. E. Escher, W. Kenneth Davis, all of California Research Corp.

(Left to right) Clyde Berg, V. R. Cooper, Robert A. McKean, R. F. Deering, George R. Lake, all of Union Oil Co. of Calif.

(Standing, left to right) Albert V. Caselli, Entertainment Committee; Charles R. Nelson, General Chairman and Technical Program Committee chairman; S. H. McAllister. (Seated, left to right) Mott Souders, Jr., Chemical Engineering Education Symposium Committee chairman; J. A. Samaniego, Arrangements Committee chairman, all of Shell Development Co.

of Standard Oil Co. of California, has worked out a procedure for dehydrating hexane using a 10-tray column of 4-ft. diameter.

First Western Meeting

The San Francisco Regional Meeting of the Institute was the first assembly of chemical engineers in the west in over 20 years and the first on the west coast, according to A. G. Stern, chairman of the Institute's Northern California Section.

Main theme of the entire four-day program, which included 17 technical papers, two symposiums, and field trips, was the tremendous growth during recent years of western chemical industries.

"The west coast industries described and inspected at this meeting," stated Stephen L. Tyler, secretary of the Institute, "are important economic factors nationally, and the work and design that has gone into the reconversion of these plants represents engineering progress to a high degree. Chemical engineers have much to learn from experiences in the western area."

Reporting on the distribution of chemical engineers throughout the country, Dr. L. W. Bass, Director of Chemical Research of Air Reduction Co. and U. S. Industrial Chemicals, Inc., stated: "It was found in recent surveys that 7.3% of the nation's chemical engineers were located on the Pacific coast, most of them in California, compared to a 1926 figure of only 6.1%. This increase," he continued, "reflects a growth of chemical engineers in the west coast region from about 500 in 1926 to about 2000 in 1943."

Dr. Bass also reported that the oil industry employs 15.7% of the chemical engineers in this country.

Although the entire western chemical industry was represented on the program, the technical discussions and attendance were predominately petroleum. Eleven of the 17 technical papers presented were either concerned directly with petroleum processes and products, or were presented by petroleum people. In the symposium on "New Western Chemical Industries" three of the 12 topics discussed were petroleum products. In addition, it was estimated that over half of the more than 700 engineers in attendance were from petroleum companies or subsidiaries.

Important Oil Papers Reviewed

Space and other limitations prevent publication at this time of the complete text of all those papers of particular interest to the petroleum industry. The following excerpts and condensations, however, represent the more interesting portions of the main ones, selected with the idea of giving the readers of PETROLEUM PROCESSING a cross-sectional view of what west coast refiners are doing. The complete papers will be published in future issues of the Institute's *Transactions*.

Phthalic Anhydride Produced From Petroleum Derivative

"Phthalic Anhydride from Ortho-Xylene," by Howard Vesper and George L. Parkhurst, California Research Corp. presented by Dr. Irving Levine, of the same company.

Phthalic anhydride until recently was used almost entirely for the manufacture of coal tar dyes. That use has been so overshadowed in recent years by demands for the material for alkyd resins, phthalic plasticizers and insectifuges, however, that total U. S. production has increased from 7,000,000 lbs. in 1932 to nearly 125,000,000 lbs. in 1944.

Until Standard Oil Co. of Calif. entered the field, operating a plant at its Richmond, Calif., refinery for Oronite Chemical Co., its chemical subsidiary, there were no producers of phthalic anhydride

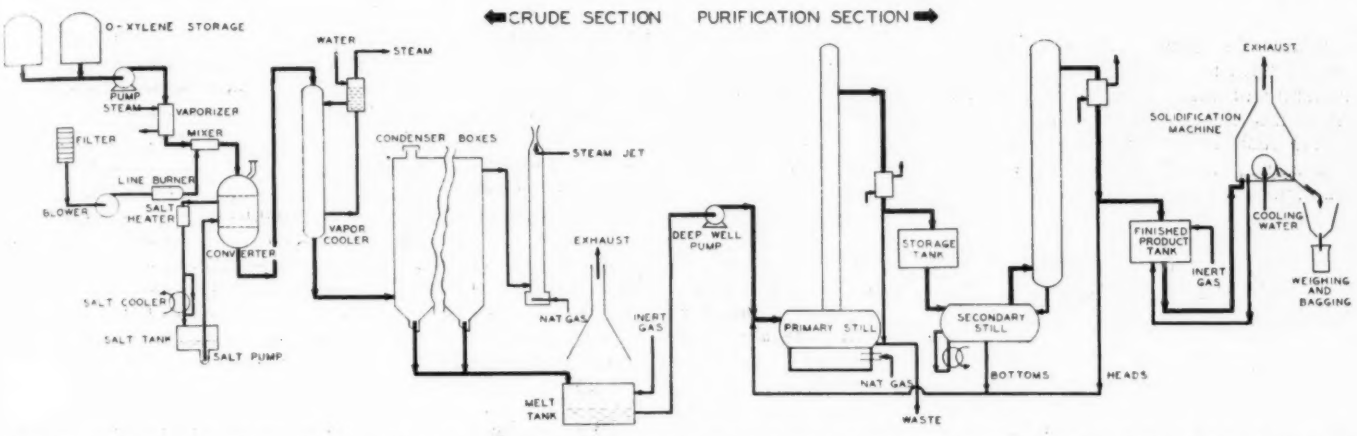


Fig. 1—Phthalic anhydride diagram showing the flow from the ortho-xylene storage to the purification of the finished product

west of the Mississippi river, although west coast demand for the chemical had risen rapidly.

Standard uses ortho-xylene, derived from petroleum, as its raw material for the phthalic anhydride plant, whereas all prior plants used naphthalenes and were therefore dependent upon coking operations for steel manufacture or coal tar distillation. Yields from ortho-xylene are said to compare favorably with the best yields reported from naphthalene.

Fig. 1 shows a flow diagram of the process employed by Standard. The plant includes eight sets of converters, condensers and attendant equipment operating in parallel, and one purification system handling the product of all eight conversion units. Total capacity of the plant is reported to be 25,000 lbs. of phthalic anhydride a day, based on 85% operating efficiency. Any or all of the eight conversion units can be operated as desired.

Ortho-xylene feed stock is pumped from one of two storage tanks through a rotameter into a steam-heater vaporizer. The amount of ortho-xylene used is roughly ½ gal. per minute for each converter operating. Air is drawn from the atmosphere through a filter and compressed by two centrifugal compressors in parallel, and preheated by means of a burner in the line. Heated air is then mixed in excess with the vaporized xylene, in the ratio of about 30 parts air to one part xylene by weight.

The air and xylene mixture pass downflow through the converter, which is essentially a tubular heat exchanger with vanadium oxide catalyst inside the tubes and molten salt outside. The salt mixture, 50% potassium nitrate and 50% sodium nitrite, is circulated through a steam boiler for removing the heat of reaction. During start ups, however, the salt is passed through a vessel containing electric heating elements and serves to heat the converter up to operating temperature.

Reaction gases from the converter are cooled in tubular heat exchangers and then passed into a large, box-like air cooled condenser where phthalic anhydride is deposited as long white needle-like crystals. As the crystals grow they break off and fall into the hopper bottoms, from which they are removed periodically. The gases pass out of the end of the condenser box and are water-washed and finally incinerated before being released to the atmosphere.

The solid phthalic anhydride is dumped into steam heated tanks for melting and the molten product then pumped into the first of two batch stills, which operate in series. Pure molten phthalic anhydride from the second still is solidified on chilled rolls, weighed and bagged for shipping.

New Solvents Developed From Acetone and Sulfur

"Dimethylsulfolane," by H. G. Staaterman, Shell Chemical Corp., and R. C. Morris, R. M. Stager and G J. Pierotti, Shell Development Co.

The sulfolanes are new solvents developed during the war years for a variety of separation processes. They are the hydrogenated forms of diolefin-derived

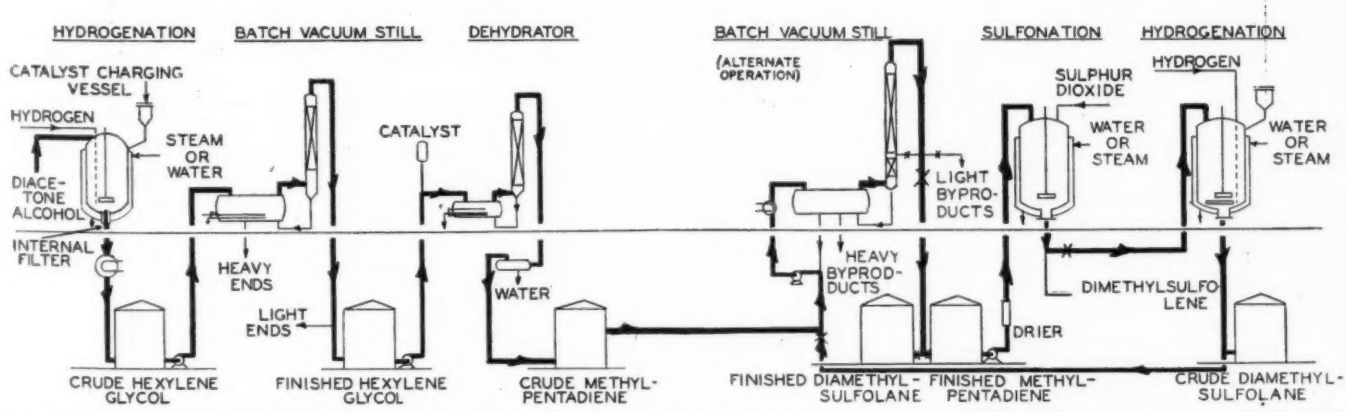
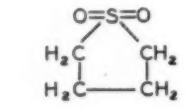
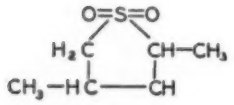


Fig. 2—Flow diagram for producing methylpentadiene from diacetone alcohol and dimethylsulfolane from the resulting methylpentadiene. One vacuum still serves for purifying both methylpentadiene and dimethylsulfolane, operating alternately on one and the other

sulfones, the name "sulfolane" being a coined term to designate the parent ring structure of these compounds. Sulfolane itself has the structual formula shown in the first diagram below, dimethylsulfolane the formula shown in the second diagram.





Because these new solvents appear to be of considerable utility and interest to industry, Shell Chemical Corp. has completed a semi-commercial plant at Martinez, for the manufacture of one of them—dimethylsulfolane.

Basically, dimethylsulfolane is a derivative of acetone, by way of diacetone alcohol, which is hydrogenated to hexylene glycol (2-methyl-2,4-pentanediol), and then dehydrated to methylpentadiene. This latter chemical, in the form of 2-methyl-1,3-pentadiene, is the starting material in the Shell process. The methylpentadiene is reacted with sulfur dioxide to give 2,4-dimethyl-3-sulfolene, which is then hydrogenated to 2,4-dimethylsulfolane.

Fig. 2 is a simplified flow diagram for the steps going from diacetone alcohol to dimethylsulfolane. Diacetone alcohol is hydrogenated to hexylene glycol in an autoclave and then batch distilled under vacuum. Distilled hexylene glycol and a catalyst are charged continuously into a reaction kettle where the hexylene glycol is dehydrated to methylpentadiene. Methylpentadiene, water and by-products enter a column, which serves to return higher boiling materials to the kettle, from which they are periodically removed. Methylpentadiene comes off as overhead, and after separation of water goes to storage and then to a batch still for purification.

Dried, distilled methylpentadiene is fed batchwise to an autoclave in which it is reacted with liquid sulfur dioxide to form dimethylsulfolene. The dimethylsulfolene is hydrogenated to dimethylsulfolane and collected in storage, from which it is periodically charged to the batch still.

Sulfolanes are effective as selective solvents for both liquid-vapor and liquid-liquid extraction processes for separating mixtures of components having different degrees of saturation or different degrees of polarity. Thus they can be used to effect the separation of aromatics from paraffins, naphthenes and olefins; to desulfurize petroleum fractions, and to refine vegetable oils.

Have Low Corrosivity

Compared with many other commercially-employed solvents such as liquid sulfur dioxide, furfural, phenol, aniline or nitrobenzene, sulfolanes are not only highly selective for many compounds but also have the advantage of low corrosivity and chemical inertness. In addition, they can be removed easily from many mixtures by a simple water wash.

The disadvantage of using sulfolanes is that they are stable only below 240° C. At higher temperatures a very slow liberation of sulfur dioxide occurs.

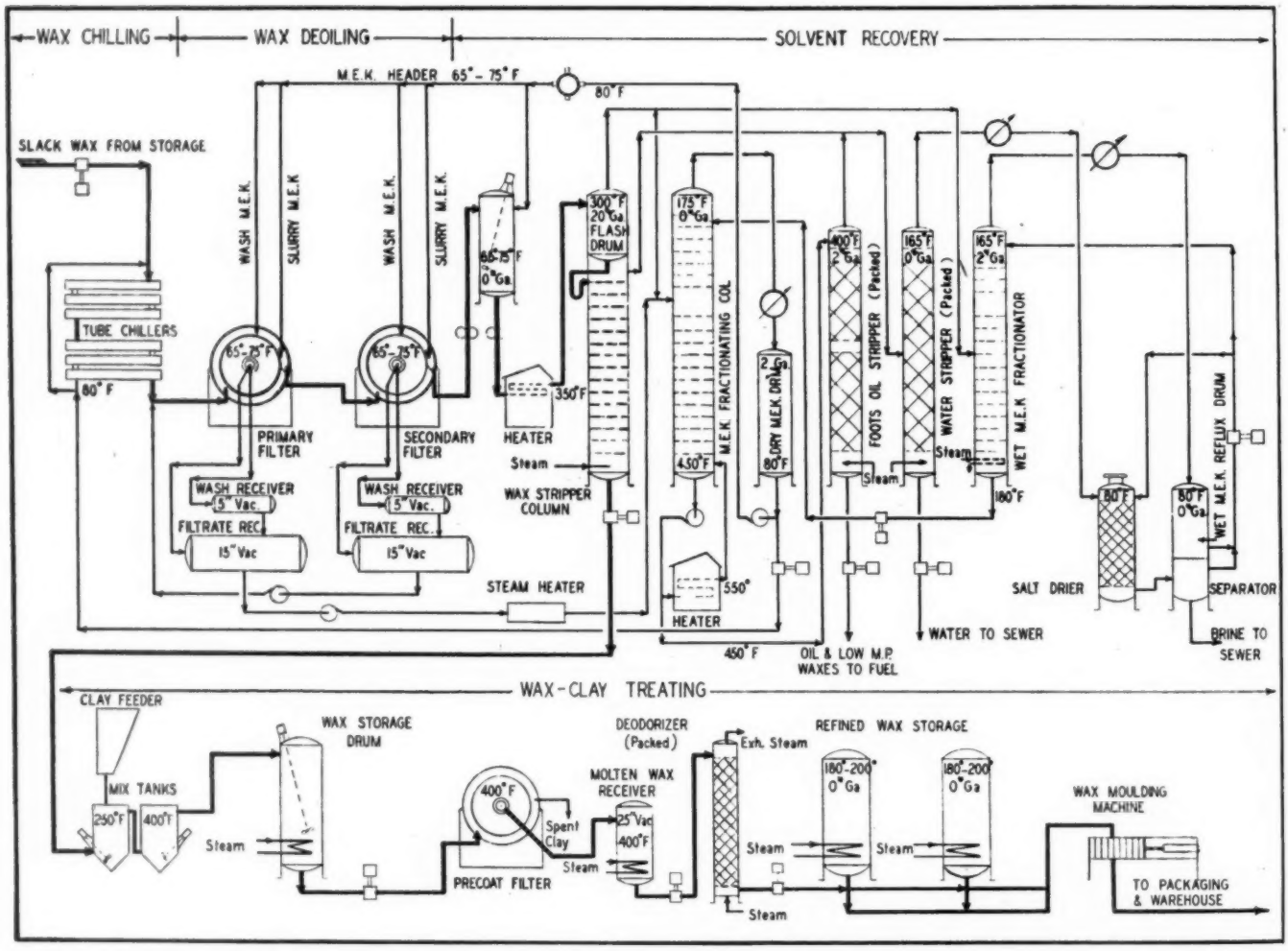


Fig. 3—Process flow sheet for wax deoiling, showing the flow of slack wax through the wax chilling, wax deoiling, solvent recovery and wax-clay treating sections of the plant

Refines Any Type Crude Wax Using Methyl-Ethyl-Ketone

"Production of High Melting Point Paraffin Waxes from California Crude Waxes," by R. A. David and P. M. Huemmer, Union Oil Co. of California.

With the advent of the production of premium grade lubricating oils from waxy California crude by solvent extraction and solvent dewaxing, some satisfactory method was needed for the disposal or utilization of the crude wax produced. The high market value of the high melting point waxes potentially available from these crude waxes provided an added stimulus in the search for an adequate process.

The sweating process normally used to separate oil from waxes was not applicable to the California crude waxes because of the nature of the waxes and associated oils. After considerable research work, a process was developed by Union Oil Co. which could be used to refine any type of crude wax. The process employs methyl-ethyl-ketone as a solvent, and has been in commercial operation at Union's Oleum, Calif., refinery since 1941. It is still the only plant on the Pacific Coast producing fully refined waxes from crude waxes.

The production of refined waxes at Oleum is divided essentially into three steps:

1.—Distillation of crude waxes.

2.—Deoiling of crude wax distillates.

3.—Decolorizing of deoiled wax fractions.

The distillation of the crude wax prior to deoiling is considered necessary in order (1) to produce cuts which will yield the desired melting point waxes on deoiling and (2) to remove undesirable asphaltic fractions incorporated during a previous dewaxing operation. The distillation occurs in a vacuum column, with two wax distillate streams being produced as side-cuts.

The second and third steps, deoiling and decolorizing, are shown in the accompanying flow sheet, Fig. 3. The principle used in deoiling is to first chill the crude wax distillate feed sufficiently to crystallize out the desired wax fractions, and then to add methyl-ethyl-ketone (MEK) as a solvent for the filtrate oil and low melting point waxes which have not crystallized out.

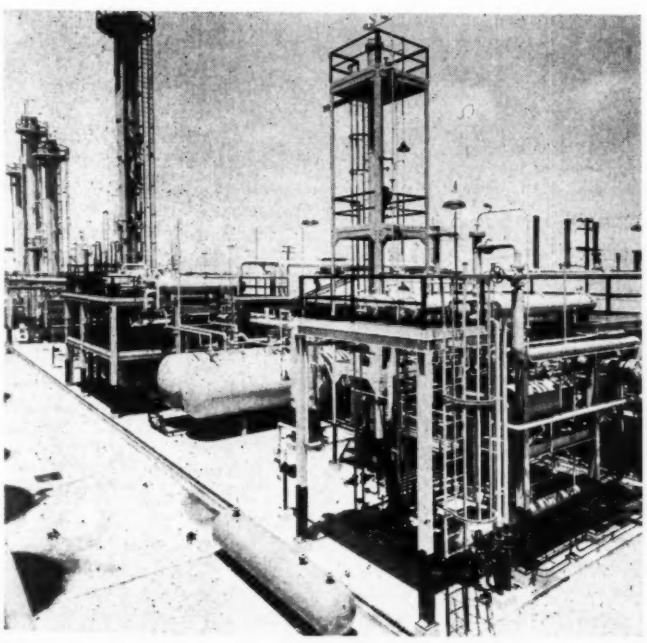
Slurry is Filtered

The MEK-oil-wax slurry is then filtered in a rotary type filter, repulped with fresh solvent and filtered in a second rotary type filter to produce wax containing well below 0.5% oil. Solvent ratios on the feed entering both the filters are approximately 3:1 MEK to feed, and both filters are operated at the same temperature, normally 68 to 75° F.

Solvent recovery, after separation of the wax from the MEK, is as shown in the flow diagram.

Decolorizing is accomplished by contact clay treating with 3-10% activated clay at 300-325° F. Two mix tanks are used and contact time is approximately 1-2 hours, depending on feed rate to unit. Spent clay is removed from the decolorized wax is a rotary type precoat filter. Natural gas is constantly fed into the system to keep the oxygen content at a minimum level and prevent color degradation of the decolorized wax.

Following filtration, the wax is steam stripped under vacuum to remove any traces of color or taste, and then pumped to storage, to be slabbed or shipped in bulk as orders demand. Wax slabs are shipped in cartons or burlap bags, or loose in paper-lined cars or trucks.



Commercial allyl chloride unit at the plant of the Shell Chemical Corp. at Houston, Texas

Allyl Alcohol and Chloride Commercially From Propylene

"Commercial Scale Manufacture of Allyl Chloride and Allyl Alcohol from Propylene," by A. W. Fairbairn, H. A. Cheney and A. J. Cherniavsky, Shell Development Co.

Allyl chloride is a highly reactive organic compound containing an active double bond and a reactive chloride bond. Its principal uses are in the manufacture of derivatives such as allyl alcohol, allyl bromide, cyclopropane, epichlorohydrin, glycerol dichlorohydrin, trichloropropane, and allyl isothiocyanate and other pharmaceuticals.

Allyl chloride is manufactured by Shell Chemical Corp. at Houston by the noncatalytic chlorination of propylene in the vapor phase at about 500° C. in adiabatic reactors. The principal reaction involved is the substitution of an atom of chlorine for an atom of hydrogen in the propylene molecule:

$$Cl_2 + CH_2{:}CH{\cdot}CH_3 \rightarrow CH_2{:}CH{\cdot}CH_2Cl + HCl$$

Allyl alcohol is also used in the manufacture of pharmaceuticals, and its esters are employed in perfumes and flavorings. In point of volume one of its most important uses is in the manufacture of thermosetting resins from esters of dibasic acids, e.g. diallyl phthalate, and from other allyl esters containing more than one unsaturated linkage.

Allyl alcohol is being manufactured commercially by Shell at Houston by the hydrolysis of allyl chloride with dilute caustic soda in a conventional pump and time tank reactor operated adiabatically, according to the following reaction:

$$CH_2{:}CH{\cdot}CH_2Cl + NaOH \rightarrow CH_2{:}CH{\cdot}CH_2OH + NaCl$$

Before this commercial plant went into operation, Shell's pilot plant at Emeryville, with a capacity of about 1500 lbs. a day, was for a considerable period of time the only source in this country of allyl alcohol in substantial amounts.

Fig. 4 gives a simplified flow diagram of Shell's allyl alcohol process. The essential units, taken in sequence of flow, are: deaerating heater for preparation of caustic solution, reactor in which hydrolysis takes place, stripping column, dehydrating column and finishing column.

Finished allyl chloride is fed to the hydrolyzing system where it is dispersed in the rapidly circulating hydrolyzer stream. The hydrolyzer, or reactor, is a vertical vessel which provides the required time for hydrolysis of the allyl chloride to alcohol. Dilute caustic solution, made up by the continuous injection of 20% caustic solution, live steam and

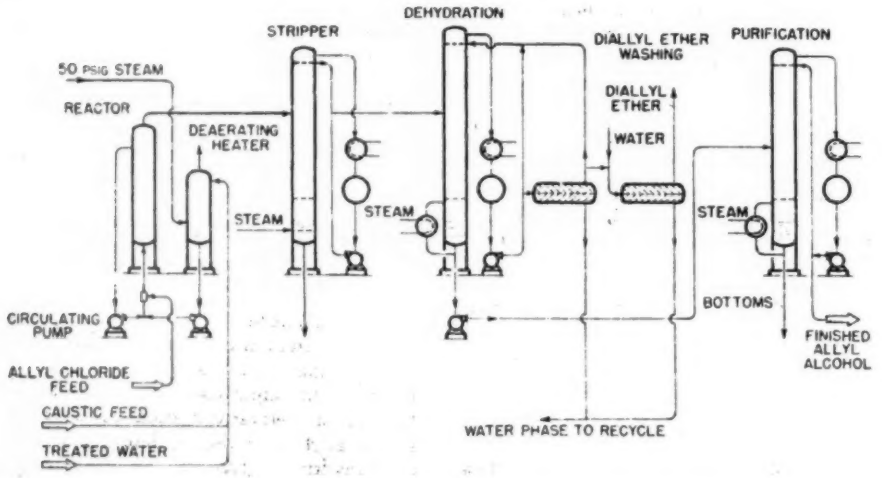


Fig. 4—Flow diagram of commercial scale allyl alcohol plant

treated water, is pumped to the hydrolyzer system at a preset rate to provide the required dilution of the crude product.

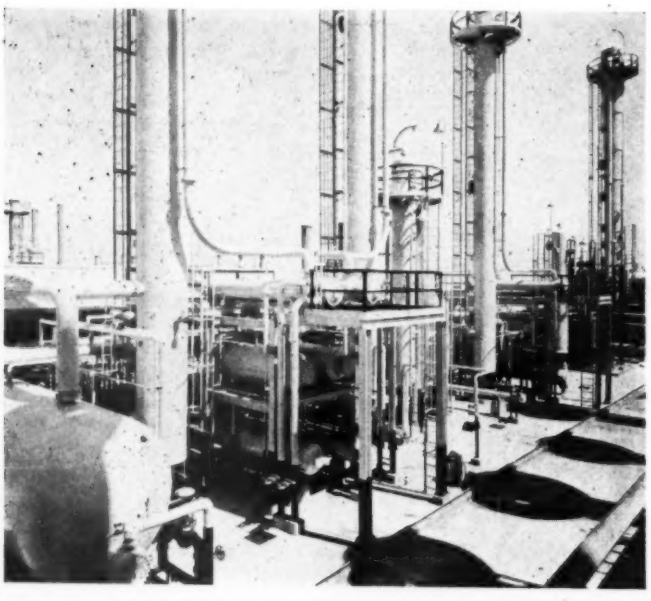
The hydrolyzer system operates at 150° C. and 200 psig, and the pH in the system is normally maintained between 10 and 12.

Product Withdrawn Continuously

Product is withdrawn continuously from the top of the reactor and is fed directly to the allyl alcohol stripper. The allyl alcohol is stripped overhead as an allyl alcohol-water azeotrope, while the bottoms (consisting of water, salt, and traces of caustic and allyl alcohol) are sent to waste disposal. The top product is condensed, part of the stream being returned as reflux and the remainder being removed as product to the dehydration step or to storage.

While batch distillation is now employed in the commercial plant, continuous rectification of crude allyl alcohol is quite feasible, employing diallyl ether as the dehydration agent. In the first step of the continuous distillation process (which has been satisfactorily operated on pilot plant scale) the ternary azeotrope of allyl alcohol, diallyl ether and water is taken overhead from the dehydration column. After condensation, a portion of the distillate is returned to the top of the column as reflux, while the remainder is sent to a phase separator. There the ternary azeotrope separates into two layers. The lower layer, containing predominately water, is recycled to the crude alcohol stripper. Part of the upper layer (predominately diallyl ether) is returned to the top of the column and an amount equal to the diallyl ether in the feed is removed from the system as crude diallyl ether. This crude diallyl ether is washed with water to remove allyl alcohol and, after settling, the washed material is sent to storage as diallyl ether product, and the lower wash water layer is recycled to the crude alcohol stripper for allyl alcohol recovery.

Bottom product from the dehydration column is sent to a second column where specification alcohol is taken overhead and small amounts of high boiling impurities are rejected as bottoms.



View at the Shell Chemical Corp. of the allyl alcohol unit. Plant is located at Houston, Texas

Produce Synthetic Ethyl Alcohol from Ethylene

"Production of Synthetic Alcohol from Ethylene," by C. M. Beamer, Standard Oil Co. of N. J., Louisiana Division.

The process for making ethyl alcohol from ethylene is quite similar to that for manufacturing isopropyl alcohols, but there are differences in the conditions necessary to make the process work. Propylene is relatively easy to absorb in sulfuric acid and is abundant in most refinery gases On the other hand, ethylene is difficult to absorb and specialized cracking operations are necessary to produce it. Also, the equipment necessary to produce ethyl alcohol must be of special construction to withstand corrosion. Large quantities of expensive alloys are needed and it is these factors that have, to a great extent, retarded the growth of the synthetic ethyl alcohol industry.

In the process for the production of synthetic ethyl alcohol, shown in Fig. 5, ethylene (preferably in concentrated form) is converted to ethyl sulfates (a mixture of mono and disulfates) by absorbing in sulfuric acid. The sulfates are then mixed with water to give ethyl alcohol and dilute sulfuric acid. The crude alcohol is purified by distillation and the sulfuric acid is concentrated for re-use.

Standard Oil Co. of N. J. was the first (1943) petroleum refiner to produce ethyl alcohol from ethylene on a commercial basis. The quality of synthetic alcohol as currently produced, it is reported, is excellent and equal to the best grades made by the fermentation of black molasses or grains. Close control reduces impurities to negligible propor-

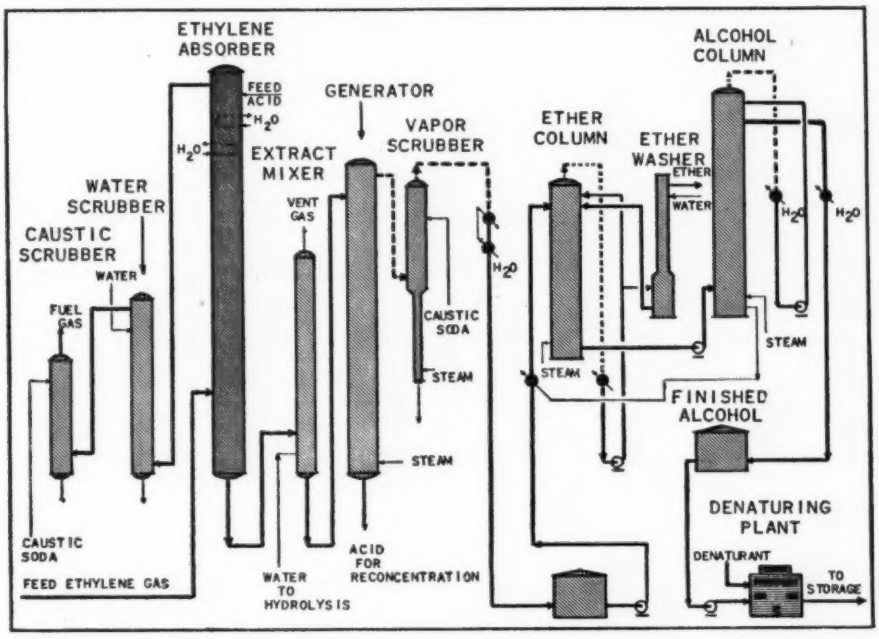


Fig. 5—Schematic flow diagram for the synthetic ethyl alcohol process

tions so that the synthetic material actually contains less impurities than fermentation alcohol.

During the war tremendous quantities of ethyl alcohol were required for the synthetic rubber program, but even when this demand falls off it is predicted that the requirements will almost surely be greater than the 123 million gallons per year average for the five years before the war.

There are also other methods of synthesizing alcohol, principally the Fischer-Tropsch process. This process may in the future become an important source of industrial ethyl alcohol, a source which in the next 5 or 10 years may have to be reckoned with by producers now using other processes.

Catalytic Process Is Used In Desulfurizing Stocks

"Catalytic Desulfurization of High Sulfur Stocks by the Cobalt Molybdate Process," by Clyde Berg, W. E. Bradley, R. I. Stirton, R. G. Fairfield, C. B. Leffert and J. H. Ballard, Union Oil Co. of Calif.

The cobalt molybdate desulfurization process developed by Union Oil Co. has been proved capable of efficient removal of all types of organic sulfur compounds present in typically high-sulfur petroleum stocks, including the more refractory thiophenes and thiophanes.

As reported in this paper, studies have shown that this process is effective in handling stocks containing 5% and more of sulfur. Product sulfur contents range from less than 0.1% for light distillates to 0.5% or less for the very heaviest distillates, including material in the lubricating oil range. The bulk of pilot plant studies have been conducted with light and heavy distillates produced by coking Santa Maria Valley crude.

Union's process employs as its fundamental operation the conversion of organically combined sulfur to hydrogen sulfide by contact with cobalt molybdate catalysts in the presence of hydrogen. The catalyst employed is comprised essentially of cobalt molybdate and alumina in the form of 3/8 by 3/8-in. pellets.

Desulfurization is associated with the consumption of hydrogen and an appreciable exothermic heat of reaction. Hydrogenation of olefins in the stock occurs, but under the conditions normally used essentially none of the aromatics present are hydrogenated. The exothermic heat of reaction is a direct function of the sulfur content and olefin content of the stock being processed. Conversion of the sulfur compounds to H_2S and saturated hydrocarbons occurs by cleavage of the carbon sulfur bonds; essentially no carbon to carbon bonds are broken. The following reactions are illustrative of the nature of those occurring during the desulfurization process:

desulfurization of ethyl mercaptan—

$$C_2H_5SH + H_2 \rightarrow C_2H_6 + H_2S$$

desulfurization of diethyl sulfide—

$$(C_2H_5)_2S + 2H_2 \rightarrow 2C_2H_6 + H_2S$$

desulfurization of thiophene—

$$C_4H_4S + 4H_2 \rightarrow C_4H_{10} + H_2S$$

Although the cobalt molybdate desulfurization process has not progressed beyond the pilot plant stage, it is said to be adaptable to a number of different programs for the utilization of sulfur-bearing crudes. One typical commercial application to produce low sulfur gasoline and cracking stocks involves coking the high sulfur crude oil and desulfurizing the full range coker distillate over cobalt molybdate. A simplified process flow sheet for such a plant is shown in Fig. 6.

Before entering the reactor, liquid feed and recycle hydrogen are preheated by heat exchange in separate exchangers against hot reaction products. Exothermic heat of reaction combined with this cracking stock is of sufficient magnitude to make the process independent of the preheat furnace except during start-up periods.

The reaction products, after exchange with the incoming feed, are further cooled and passed to a gas separator. The liquid product from the separator is given a caustic wash to remove dissolved H_2S and a final water wash to remove caustic carry-over. Recycle gas from the separator is purified of H_2S and hydrocarbons by absorption at reaction pressure in a conventional oil absorber-stripper system, and returned to the incoming hydrogen stream.

Four reactors are employed in this design, and are manifolded so that three may be on stream at any time while the fourth is being regenerated. Regeneration is accomplished by adding air to a stream of inert combustion gas which is circulated over the catalyst by means of a blower. Inert gas for this purpose and for purging is generated by burning fuel gas in a special furnace.

Under these conditions nearly 100% yield is obtained of a 0.5% sulfur content distillate which may be readily utilized in conventional refinery opera-

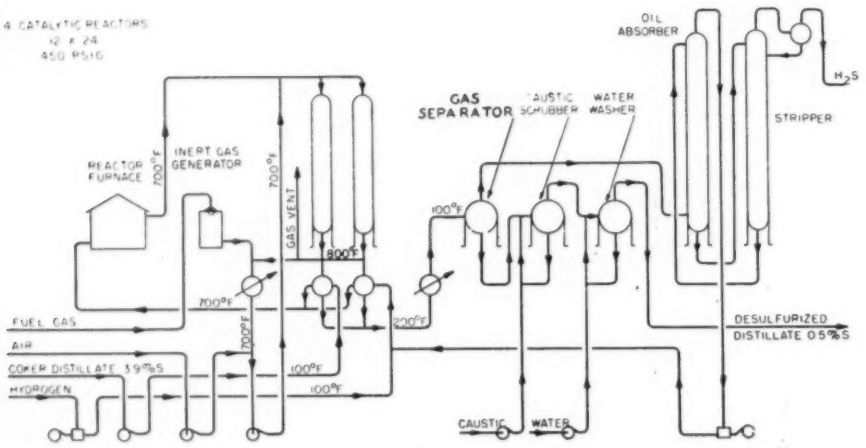


Fig. 6—Simplified process flow sheet for a catalytic desulfurization plant

tions as feed stock for upgrading by further catalytic treating or as blending stocks for gasoline and diesel fuels. Even under these mild conditions an appreciable make of gasoline is realized, and the physical characteristics of the gas oil produced are greatly improved over those of the feed.

Removes Troublesome Water From Light Hydrocarbons

"Design and Operation of a Light Hydrocarbon Distillation Drier," by G. C. Gester, Jr., California Research Corp.

Dehydration of light hydrocarbons is necessary wherever the water held in solution at ordinary temperatures may prove to be a source of trouble in some subsequent processing step. Ice formation, hydrate formation, decreased catalyst activity, or increased corrosion are examples of problems which have arisen as a result of insufficient removal of water by decantation alone.

The problem which prompted the work described in this paper was the formation of ice crystals when saturated hexane, mixed with waxy lubricating oil stock, was chilled to below —50° F. in a well-known solvent dewaxing process. The difficulty was successfully overcome by the installation of a distillation drier, after a chemical drier was found unsatisfactory.

The determination of vapor-liquid equilibria for the water-hexane system constituted an important part of the investigation, with the result that it was possible to evaluate the performance of this column to yield plate efficiencies useable in future designs. In the investigation it was found that the use of Henry's Law in obtaining vapor-liquid equilibria introduced no appreciable error.

Fig. 7 shows a flow diagram of the hexane distillation drying section in a lubricating oil dewaxing plant. The heat and material balances shown were obtained during normal plant operation. The column is 4 ft. in diameter and contains ten full cross-flow bubble cap trays.

The applicability of distillation as a means of dehydration is limited by the water content of the stream to be dried, or by the high initial expenditure required for a column of many plates when reducing the water content to extremely low values.

Before the installation of the distillation drier, a lime drier was installed to dehydrate the dewaxing plant hexane. It was found however, that small traces of phenolic materials in the hexane reacted with the lime to produce a precipitate so fine that it could not be satisfactorily removed by filtration. In addition, the operation of this equipment, which had to be intermittent in order to change the lime, was not only more tedious but also more expensive.

Although no formal analysis was prepared, the general experience obtained with these two types of driers in identical service indicated that for a stream of fairly constant water content flowing at a steady rate, distillation drying is to be preferred on the basis of lower operating costs and greater ease of operation. It should be noted, however, that when the water is likely to come intermittently or as entrained "slugs," the maximum water which a distillation drier can be removed is dictated by the dew point composition of the overhead vapor and its rate. In such cases a chemical drier might provide more adequate protection.

Reprints

Reprints of any articles appearing in PETROLEUM PROCESSING ordinarily are made only on order. Because present conditions prevent our holding the type after an issue is published, inquiries for quantity reprints should be forwarded promptly after receipt of the issue, by telegram if possible. Reprints ordered after the type has been broken down have to carry the additional cost of resetting the article.

Should you desire an article reprinted for you, **please order the reprints promptly.**

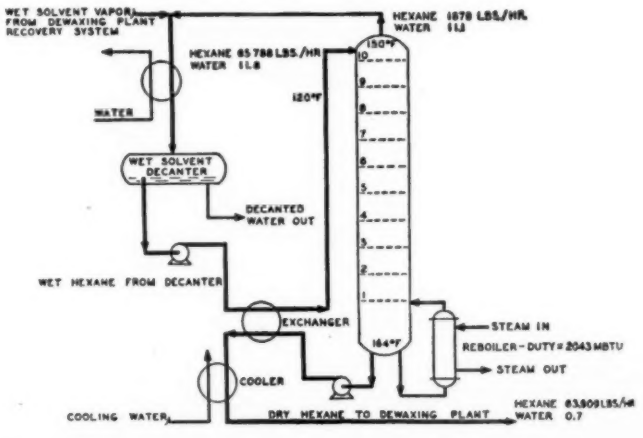


Fig. 7—Schematic sketch of the flow through a hexane distillation drier

HOUDRY LICENSEES get the benefit of HOUDRY RESEARCH

Houdry Laboratories, with unexcelled physical equipment for catalytic research, are staffed by scores of top-flight chemical engineers, mechanical engineers, process engineers, metallurgists, economists and specialists in refinery operation. Their research is for the benefit of Houdry licensees, helping them to attain the optimum in quality and volume of output at the minimum operating cost.

A large proportion of royalties received from Houdry licensees is reinvested in such research for their common benefit. New processes, improvements in existing processes and catalyst research are the subjects of searching inquiry which inevitably will serve to keep Houdry licensees abreast or ahead of major developments in refining techniques.

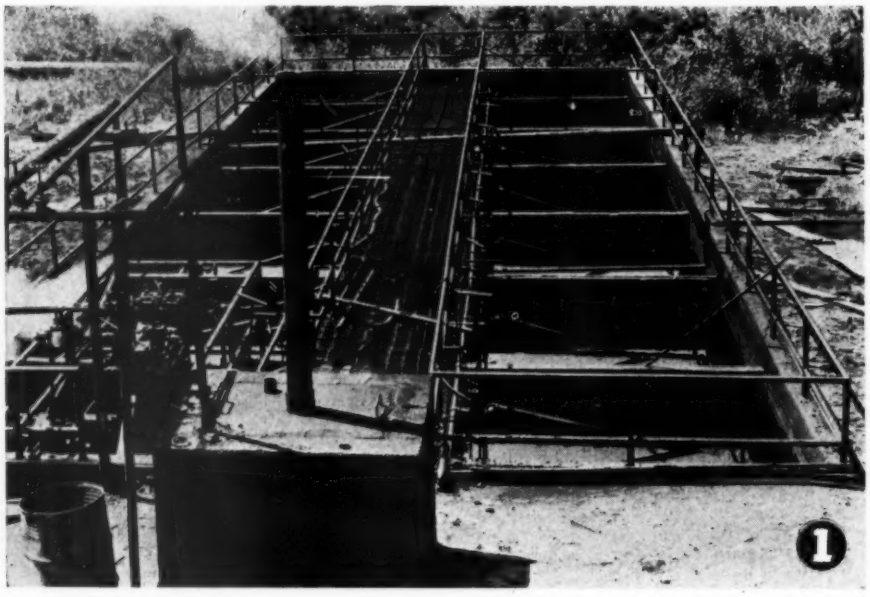
There is more catalytic "know how" in Houdry Laboratories than can be found in any similar scientific organization, regardless of size or sponsorship.

HOUDRY CATALYTIC PROCESSES

HOUDRY PROCESS CORPORATION

25 Broad Street, New York 4, N. Y.

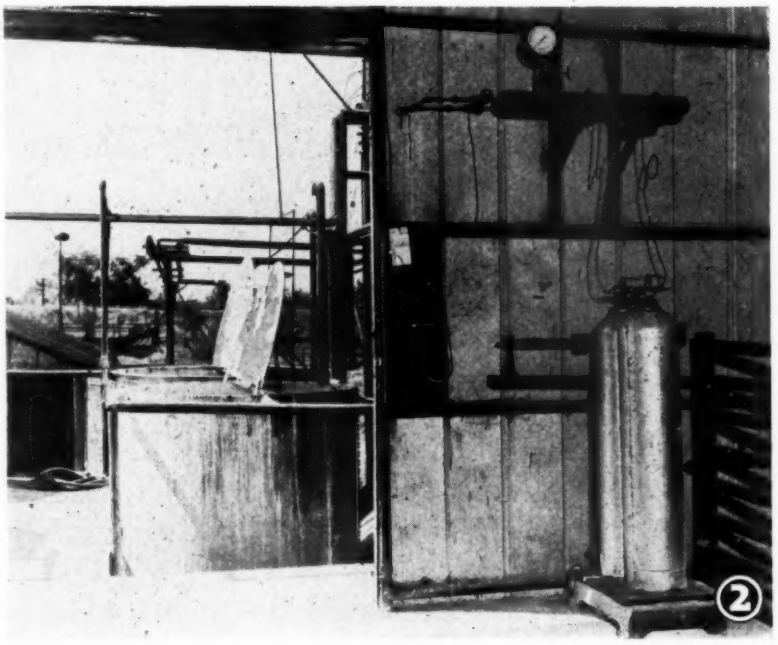
Wastes Reclaimed; Used as Cooling Water



Two problems—proper disposal of refinery wastes and meeting the water shortage during the hot, dry season—were solved by Talco Asphalt and Refining Division, American Liberty Oil Co., at Mt. Pleasant, Texas, by a waste treatment system installed late in 1944.

The reclaimed water has been used successfully for cooling purposes for the past two years. Details of the system are given in the photographs and flow diagram on the accompanying pages. Units shown in photographs are keyed by number to indicated positions on the flow diagram.

1 Primary Oil Separator. All refinery wastes are conveyed by a common sewer to this unit and then to the secondary oil separator (not shown), removing practically all the free oil. Effluent from these units still contains emulsified oils, sulfur compounds, caustic from the gasoline treating plant, wash water from various units, boiler and cooling tower blowdown, as well as other contaminants. It is highly alkaline, odorous, and turbid. Flow, averaging 75 g.p.m., was previously discharged to a small creek near the refinery.



2 Flow from the oil separators is mixed with sulfuric acid, copperas, and chlorinated lime slurry. Pictured here is chlorinated lime preparation. Slurry is made up in tanks in middle background (with open hatches), chlorine is weighed in from cylinders on scale in right foreground. Mixture is 18 lbs. of chlorine to 100 lbs. hydrated lime.

Sulfuric acid neutralizes the water to 7.0 pH, also aids in breaking out of emulsified oil. Copperas or ferrous sulfate precipitates out undesirable sulfides as iron sulfides. Chlorinated lime oxidizes ferrous ion to ferric ion, and removes unpleasant odors. Mixture of water and various chemicals then moves on to settling basin shown in 3.

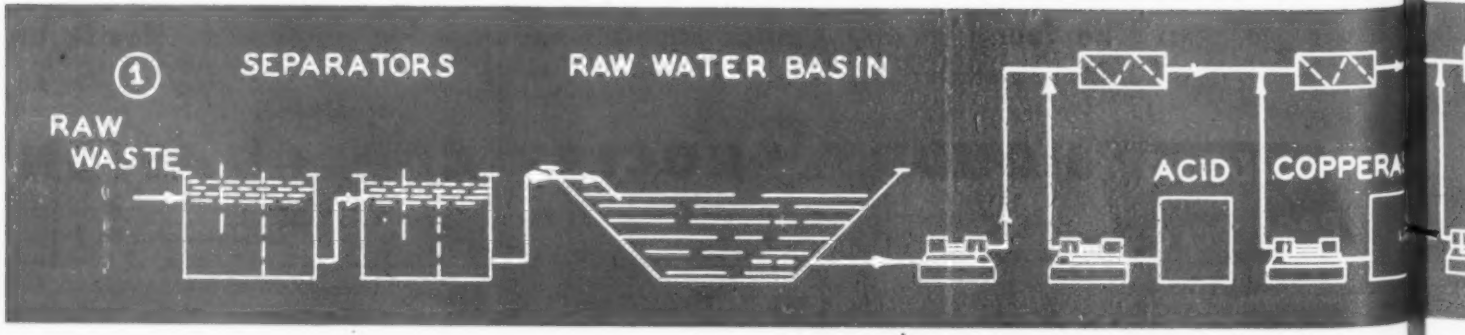
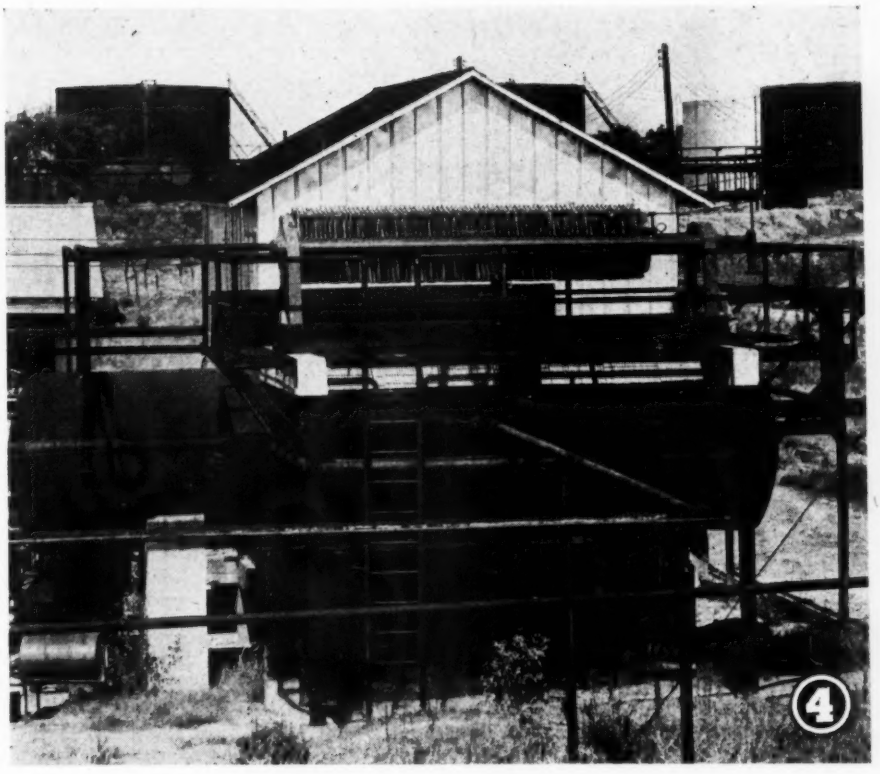


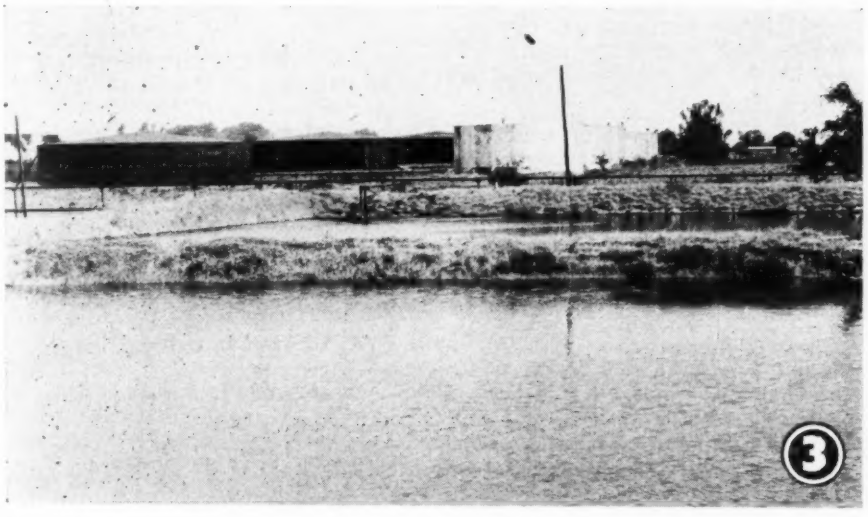
TABLE 1
Analysis of Water Before and After Treatment

	Before	After
Total Hardness, as $CaCO_3$	0	48
Alkalinity, as $CaCO_3$		
Phenolphthalein	580	0
Methyl Orange	830	98
Chloride, as Cl	210	226
Sulfate, as SO_4	86	442
pH	11.6	7.4
Oil	Pres	None
Sulfide	Pres	None
Turbidity	1000+	50—
Odor	Bad	Good

The treatment cost of 15c/1000 gals. of water is not considered high by Talco management inasmuch as it is the means for providing an ample supply of cooling water for the plant.

The material presented on these two pages is from a paper entitled "Disposal Water Treating at Talco Refinery," by C. G. Rook, Talco water chemist, given at the Wichita regional meeting of the Western Petroleum Refiners Association, Sept. 26.



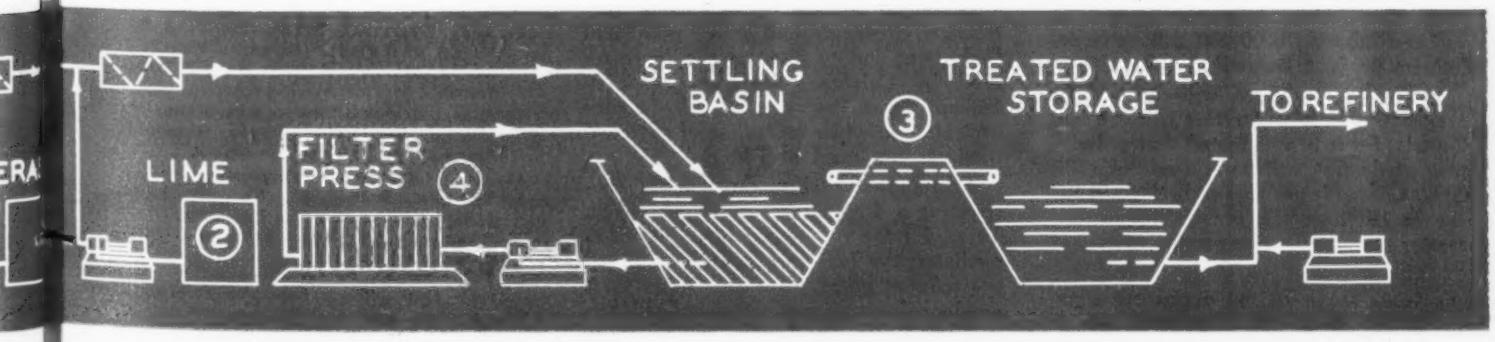


3 **In the 2,500,000 gallon settling basin (shown in background), measuring 200 x 125 x 15 ft., the heavy floc of ferric hydroxide, together with suspended solids, emulsified oil, and precipitated sulfides settles to the bottom. The calculated retention time in this basin is 23 days. Clear effluent passes to a treated water storage basin of similar dimensions and capacity (shown in foreground), and is reused as cooling water, or discharged into nearby streams.**

4 **Filter Press and Sulfuric Acid Storage When an appreciable volume of sludge has accumulated in the settling basin, it is withdrawn by means of a high head centrifugal pump and sent through the one ton filter press. The sludge as filter cake is used for fill dirt around the refinery yards; the clear filtrate flows by gravity back into the settling basin.**

Talco buys its sulfuric acid in tank car lots in concentrated form, dilutes it to desired strength, and mixes it with waste by means of proportioning pumps. Copperas, procured in 100 lb. bags in car load lots, is also mixed with proportioning pumps in the ratio of 1 lb./gal. of waste water. Chlorinated lime slurry is also mixed with proportioning pumps after makeup.

Baffle-type mixers, 6 in. diameter, 4 ft. long, are used for each treating solution. Water is maintained at 7.0 pH after sulfuric acid treatment. Charge pump for treatment system is 350 gpm single stage centrifugal.



TOMORROW

...IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Other companies are expanding their output of petroleum chemicals.**
- **Oil companies study the use of fissionable materials.**
- **Automobile production faces new series of hurdles.**
- **Jet fuels continue to undergo investigation.**
- **A German-developed synthetic rubber tackifier makes its domestic appearance.**
- **New producer reemphasizes importance of ethylene glycol.**

Other Companies Expanding Petroleum Chemicals Output

WHILE Wyandotte's plans are the recent "big news" because they involve a new producer, many companies already engaged in petroleum chemicals production are materially increasing the quantity and diversity of their products.

Monsanto Chemical Co., for example, has recently purchased from the War Assets Administration, for $9,550,000, the 50,000-tons per year styrene monomer plant which it built and operated at Texas City, Texas, during the war for the production of styrene for the synthetic rubber program. For a time, at least, it is probable that most of the plant's output will continue to be committed to the Rubber Reserve Co. use for this same program. A recent announcement, however, states[1] that "Monsanto Chemical Co. expects to begin construction about the middle of September on its styrene plastic plant at Texas City."

This same report mentions a figure of $1,252,000 as the cost of this polystyrene plant, which is part of Monsanto's nationwide $14,000,000 expansion program. According to H. K. Eckert, manager of the Texas City plant[1], Monsanto will be producing polystyrene resins at a rate in excess of 80,000,000 pounds per year by 1947. The Texas City plant, incidentally, will use "about 15,000,000 gallons of petroleum products annually."

Monsanto's projected capacity will be over half the total for this country and Canada, for it is anticipated that polystyrene production will be at a rate of 150,000,000 pounds per year or better in 1947 —over 15 times the prewar output and greater than the entire prewar output of all thermoplastic molding compounds. Chief advantages of this plastic, in addition to other desirable properties, are its present low cost—less than 25 cents per pound for the molding compound in carload lots, and low specific gravity—another factor making for low costs in use.

The Koppers Co., Inc., has also purchased from the War Assets Administration the styrene facilities at the Government-owned Kobuta, Pa., butadiene and styrene plant built and operated during the war by Koppers United. Only the styrene facilities were involved in this $3,265,000 transaction, but Koppers also will use "certain common facilities" at Kobuta.

According to report, Shell Union Corp. has recently alloted $10,000,000 to the Shell Chemical Corp. for the construction of new plant facilities. This figure presumably includes the $6,000,000 chemical plant for which Shell received CPA construction permission in June, but may or may not include the new glycerin epichlorohydrin and isopropyl alcohol plants which are nearing completion near Shell's Deer Park refinery. These units will cost a total of $3,000,000, and the latter will increase Shell's isopropyl alcohol capacity by 100,000,000 pounds per year.

The Celanese Corp. of America is constructing a $3,000,000 research center near Corpus Christi, Texas, to study petroleum chemicals and other petroleum derivatives and to improve the processes used by Celanese's chemical plant at Bishop, Texas. Research will also be concentrated on wider utilization of chemical products produced at Bishop.

As reported earlier, du Pont is constructing a $30,000,000 plant at Orange, Texas, for the production of nylon intermediates; the Jefferson Chemical Co. will use refinery gases from The Texas Co.'s nearby refinery to produce chemical intermediates in a plant being constructed at Port Neches, Texas; and American Cyanamid is constructing a plant at Port Neches to produce a variety of industrial chemicals from intermediates manufactured by Jefferson Chemical.

It is interesting to note[2] that part of Standard of New Jersey's plant expansion at the Baton Rouge refinery of its Louisiana division includes a new synthetic alcohol unit. According to M. W. Boyer, general manager of the refinery, "when the new alcohol unit is completed, Baton Rouge will be one of the most important centers of synthetic alcohol production in the country."

Regardless of the unannounced capacity of this new plant, this statement is easily understood when it is considered[3] that the present annual output of the Baton Rouge refinery is said to be 6,000,000 gallons of ethyl alcohol and 12,000,000 gallons of isopropyl alcohol. It is also interesting to note that Jersey Standard continues to add to its synthetic alcohol capacity on the one hand while voicing uncertainties as to the future of this product on the other[4].

All of this activity in the production of petroleum chemicals is indicative of the widespread feeling that the surface of this field has scarcely been scratched. When construction materials become easier to get, it is likely that the present boom in the construction of new petroleum chemical plants will rise to even greater heights. As previously mentioned, caution and good judgment must be observed, but many petroleum companies which have hesitated for years about taking the plunge are likely to at least get their feet wet.

Use of Fissionable Materials Studied by Oil Companies

QUITE apart from the very real threat which "uncontrolled" use of atomic energy offers to world peace and to civilization itself are the peacetime miracles which fissionable materials may make possible. Because of the rapid rate of technical development of the petroleum industry, it is therefore no surprise to note in a recent article[5] that "considerable interest (in radioactive isotopes) has already been expressed by industry, particularly by oil companies—including Standard of California, Houdry, Shell, Socony-Vacuum, and Gulf."

These companies—and others—are interested in the use of radioactive mate-

(1) Anon., NATIONAL PETROLEUM NEWS 38, No. 36, 62 (1946), "Monsanto Plans to Build Styrene Plastic Plant."

(2) Anon., NATIONAL PETROLEUM NEWS 38, No. 36, 62 (1946), "Expansion Plan Told As Baton Rouge Refinery Runs Billionth Barrel."

(3) Anon., NATIONAL PETROLEUM NEWS 38, No. 36, 58 (1946), "Seeks Permanent Approval for Trucking of Alcohol."

(4) Anon., NATIONAL PETROLEUM NEWS, *Technical Section*, 38, No. 27, R-489 (1946), "Tomorrow in Petroleum Technology—Alcohol from Petroleum Faces Future Problems"; Parks, J. G., *Chem. & Met. Eng.* 53, No. 9, 116 (1946), "Solvents Face Difficult Expansion Problems."

(5) Anon., *Business Week*, No. 884, 5 (1946), "Isotopes for Industry."

rials for a variety of reasons. Such substances are of increasing importance in certain petroleum exploration studies, where the high cost of radium previously restricted but did not eliminate their application. From such studies, in the laboratory and in the field, will come increased quantities of the petroleum locked in the earth.

As regards refining, isotopes of carbon are invaluable for use in the study of reaction mechanisms. The understanding of the course of a reaction, in turn, is of the greatest importance to its economic application.

Petroleum and its products are chiefly hydrocarbon in nature, so that the availability of carbon atoms of different atomic weights will make it possible to follow certain compounds or radicals through an intricate series of reactions with unerring accuracy. This is done largely through the mass spectrometer, in whose use the petroleum industry is already a leader because of its application to the field of hydrocarbon analysis.

As reported earlier[6], Sun Oil is building two plants to separate carbon atoms having an atomic weight of 13 from ordinary carbon, 98 92% of which has an atomic weight of 12. Of equal significance is the report[7] that C-14 is among the some 100 radioactive by-products of uranium fission which are currently being sold in limited quantities by the Army's Manhattan District.

The use of these two carbon isotopes—C-13, incidentally, is not radioactive—will enable the petroleum industry to learn much that has previously been concealed from it. It is even probable that both isotopes will be used in the same hydrocarbon studies when it is necessary to observe the behavior of more than two groups (C-12, the normal isotope, will also be used, of course).

The petroleum industry is by no means the only one interested in carbon isotopes—medical research is equally excited about the opportunity to use carbon isotopes (especially the harmless C-13) to trace the chemical reactions in living processes, for here too carbon compounds play a dominant role. Space does not permit further discussion of all the intriguing possibilities afforded by the availability of isotopes, radioactive and otherwise. However, it is certain that they will find use in *many* fields.

Meanwhile, much attention continues to be given to the all-important economic aspects of the commercial use of the energy released by nuclear fission. American scientists recently told the United Nations that a nuclear power plant having a 75,000 kilowatt capacity could probably be constructed and fully equipped for $25,000,000 in any normal location in the eastern U. S.

At capacity, however, the normal operating cost of this plant would be approximately 0.8 cent per kilowatt hour, which may be compared with an operating cost of 0.65 cent per kilowatt hour for a power plant using coal. Furthermore, the latter plant would cost only $10,000,000 to construct under the same conditions.

The nuclear plant would also produce radioactive isotopes, of course, but it is likely that this would have little effect on power production economics. It is true, however, that the nuclear plant would be able to supply heat and process steam directly, in addition to power.

In spite of the unfavorable comparison offered by these figures, it is significant that they are even of the same order of magnitude, considering the early "state of the art" of nuclear energy. Furthermore, it is entirely possible that nuclear energy plants could be shown to have economic advantages for construction and use in isolated and remote areas.

In regard to the use of nuclear energy in mobile equipment, the Army Air Forces has recently commissioned the Fairchild Engine and Airplane Corp. to undertake an extensive research program on the possibilities of operating airplanes by nuclear energy. According to Major General Curtis E. LeMay, Deputy Chief of Air Staff for Research and Development, this work is purely exploratory, and security requirements prevent discussion of details of the program. No "final solution" has yet been found, however, and no date has been set for the completion of the project.

It is impossible, even after a year of raging discussion, to envision anywhere near all of the ramifications of the discovery of controllable nuclear fission. Nevertheless, it is certain that many of these ramifications will directly affect the operations of the petroleum industry.

Automobile Production Faces Continued Series of Hurdles

DESPITE such encouraging statements as the one made in early September by Charles E. Wilson as to the possibility of a production rate of 6,000,000 cars per year by this time next year—much misquoted by such headlines as "Six Million Cars Possible in '47, GM Head Says"—The automobile industry faces a future which appears to contain an endless series of barriers to the attainment of peak production.

Wilson blames past curtailed production on continued strikes, shortages of parts and equipment, a decline in labor efficiency, and (indirectly) on the uncertainty of Government wage-price policy, which he said was changed three times from August, 1945, to March, 1946. General Motors produced only about 400,000 cars in the first year after the war instead of the scheduled 1,400,000. "From now on," according to Wilson, "the shortage of basic materials will be a problem."

This last opinion is shared by the entire industry, which must cope with a shortage of steel, pig iron, lead, and copper. Pig iron is in particularly short supply; although blast furnaces are operating at close to 70% of capacity—an improvement of 15% or more since July 1—an 80%-of-capacity rate is considered minimum for present needs. Steel mill operations are providing sheet steel and strip at 90% of capacity, but automobile industry purchasing agents are perturbed by the fact that their field got less than its historic share of these products in the early part of this year.

Copper stockpiles are still depleted by the early 1946 mine and refinery strikes, and much of the Government's large stockpile is not in the required shapes and sizes. Furthermore, it cannot be remelted and sold under present price ceilings. The Government may absorb the cost of this operation, however.

Lead for soldering radiator cores is obtainable only: (1) in competition with other heavy users, or (2) from secondary lead scrap—at present almost unavailable because most scrap dealers are waiting for a price increase.

Shortages are getting worse instead of better, and there is still no assurance that crippling strikes in plants of parts suppliers will not continue to plague the industry. Based on steel supplies alone, car production may be limited to 4,800,000 assemblies next year, while the outside limit even by 1948 may be only 5,400,000.

All this is not encouraging news to the petroleum industry, which depends upon automobiles for the consumption of its chief product, gasoline. The unexpected durability of old automobiles[8] has proved a boon to revived gasoline consumption, but there is no definite assurance that these cars will be capable of use at the present rate until new cars are available in sufficient quantity to "take over." Nevertheless, the petroleum industry must hope for the best, meanwhile keeping a close watch on car production and registrations.

Jet Fuels Continue To Undergo Investigation

Army Air Force research at Wright Field continues to be concerned with the optimum properties of fuels for turbo-jet-propelled planes, in addition to aeronautical investigations on the planes themselves. The petroleum industry is also engaging in similar research, and it is apparent that cooperation exists in this field, for the AAF has recently offered to

(6) Anon., NATIONAL PETROLEUM NEWS, *Technical Section*, 38, No. 6, R-89 (1946), "Tomorrow in Petroleum Technology—Sun Oil and Houdry Corp. Announce Carbon Isotope."

(7) Anon., *Business Week*, No. 876, 17 (1946), "Peaceful Atoms."

(8) McIntosh, A. J., NATIONAL PETROLEUM NEWS 38, No. 32, 7 (1946), "Extended Life Span of Autos Bodes Well for Oil Industry."

loan captured German jet aircraft engines to petroleum refiners who are interested in the developmnt of more effective jet fuels[9].

As has been pointed out before in this series[10], jet fuels are far from being "ordinary kerosine." The latter might have too high a freezing point, poor stability, corrosiveness, etc. Present specifications for the "refined kerosine" now in use are somewhat as follows: (1) freezing point—no higher than —75° F.; (2) flash point —110° F.; (3) distillation range—10% point of 410°F. and 90% point of 490° F.; (4) sulfur content—less than 0.2% by weight; (5) bromine number—not higher than 3.0; (6) viscosity—not higher than 10 centistokes at —40° F.; and (7) no copper strip corrosion[11].

Storage stability is also an important factor, as is the chemical composition of the fuels themselves. The higher the aromatic content, the higher the heat of combustion, but "fuels of high aromaticity tend to produce more carbon and smoke upon ignition," leading to deposits which "foul the fuel injection nozzles and other parts of the jet combustion chamber, with resulting loss of efficiency. To achieve the proper balance between these two factors, methods for determining the aromatic components are being studied. Eventually, with the progress of jet engine research, critical fuel factors will be evaluated so that a highly efficient jet fuel will be developed[11]."

German-Developed Tackifier Makes Domestic Appearance

It is interesting to note that one of the many German war-developed chemicals, "Koresin," is now available for domestic use in at least experimental quantities[12].

This chemical, the condensation product of p-tertiary butylphenol with acetylene in the presence of zinc naphthenate, has been found to be very valuable for imparting tack to GR-S, a property in which this synthetic rubber is somewhat deficient. Proper tack, however, is a vitally required property for the construction of good tires.

For coating GR-S stocks, the Koresin is normally applied in naphtha solvent (sometimes with 10% toluene added). Naphthas are also used in the compounding of Koresin-containing GR-S "rubber" cements.

"Koresin" is an interesting compound for two reasons: (1) it adds to the utility of GR-S, a synthetic rubber in whose manufacture the petroleum industry has a definite interest, and (2) its synthesis is chemically similar to various "chemicals from petroleum"—in fact, it can be so synthesized, if desired. Its possible domestic use will be viewed with some attention by rubber, chemical, and petroleum interests.

New Producer Reemphasizes Ethylene Glycol's Importance

IT is an interesting coincidence that several companies which have in recent years engaged in the manufacture of chemicals from petroleum have made their entry into this field through the manufacture of ethylene glycol and related products.

As is well known, the pioneer in this field was Carbide and Carbon Chemicals Co. which reigned supreme until the expiration of the basic patents on its first process—the hypochlorination of ethylene, followed by hydrolysis. Almost simultaneously there was a ruling of invalidity (for legal, not technical reasons) on the basic patent on its second process—the catalytic oxidation of ethylene, followed by the hydration of the ethylene oxide.

A number of companies using both processes are now producing ethylene glycol and some of its derivatives and byproducts—U. S. Industrial Chemicals, Dow and so on. Any chemical which can sell wholesale for over $1 a gallon is still of interest to many companies, especially when this chemical can be produced from inexpensive petroleum hydrocarbons. So it is not surprising that the Wyandotte Chemical Corp. has decided to enter the field of organic chemical manufacture through the production of an ethylene glycol-propylene glycol mixture.

Various accounts of the announcement of this part of Wyandotte's $25,000,000 expansion program have mentioned that the company will use "a process not now in commercial operation" and that "it differs somewhat from customary manufacture." Raw materials, however, are said to be petroleum, chlorine, and caustic soda, so that it may very well be that the chief difference involved is the joint hypochlorination and (alkali) hydrolysis of ethylene and propylene to produce the mixed glycol which Wyandotte plans to market.

Actually, this decision to produce a mixed glycol instead of chemically pure separate ones may prove an effective move in a well-developed field. If the process variant developed by Wyandotte can obtain (as is likely) good yields from a mixed ethylene-propylene gas, the cost of completely separating these olefins is thereby eliminated. The resultant mixed glycol may not have as "good" properties as the pure ethylene glycol but its quality will certainly be high enough for use as "permanent-type" antifreeze. Its lower cost will probably enable it to hold its own in competition for the other uses of ethylene glycol as resins, cellophane, dynamite, etc.

Wyandotte does not intend to confine its entry to this single petroleum derivative. Its glycol plant which will be in operation early in 1947, will also produce chloroethers, polyglycols, ethylene and propylene dichlorides, and solvent naphthas. The exact size of the plant is not clear from published reports. Two sources quote a figure of 100,000,000 pounds per year, while another mentions "35,000,000 gallons of antifreeze and other glycol derivatives yearly". This is not a good correlation by any means; since ethylene glycol weighs over nine pounds per gallon but it is clear that the plant is of considerable size. To provide the necessary chlorine, Wyandotte is expanding its already considerable chlorine production.

A synthetic detergent plant will be completed in the fall of 1947. This unit will produce an "alkyl aryl sulfonate type" of synthetic detergent, also presumably from petroleum raw materials. Most of this detergent will be marketed in competition with soap, but part of its production will be incorporated in Wyandotte's cleaning compounds.

The company is also building a number of versatile, "oversize pilot plants" to produce a variety of "fine chemicals" for which markets are to be sought. These chemicals are said to include sodium xylene sulfonate and certain benzene sulfonic derivatives such as benzene sulfonamide and alkyl benzene sulfonates.

Wyandotte is not confining its expansion to the organic chemical field. It is also increasing its capacity for its major inorganic products. While this company is not in the same size group as du Pont, Union Carbide, Allied Chemical, Dow, and Commercial Solvents, it is by no means a small company, and its entry into the petroleum chemicals field is significant of the continued possibilities offered by the use of petroleum raw materials.

Nevertheless, attractive as these prospects may be, petroleum refiners must move with caution before engaging in a field as complex as chemical manufacturing. Wyandotte has the advantage of an existing, experienced marketing organization, and its entry is not dependent entirely on the success or failure of a single product. There are many other rules for this game, as has been mentioned before in this series, but it is centainly one which many refiners would like to learn to play.

(9) Anon., NATIONAL PETROLEUM NEWS 38, No. 28, 47 (1946), "Refiners Invited to Use German Engines for Jet Fuels Work."

(10) Anon., NATIONAL PETROLEUM NEWS, *Technical Section*, 37, No. 18, R-364; No. 27, R-558 (1945), "Jet Propulsion Fuels."

(11) Anon., *Industrial and Engineering Chemistry* 38, No. 7, Suppl. p. 5 (1946), "Jet Propulsion."

(12) Anon., *Koresin, Tackifier for GR-S Rubber*, General Anilene & Film Corporation, New York, Preliminary Data Bulletin No. 201, 1945.

what's new
in petroleum refining

PRESSURE-FLOW DESIGN IN "FLUID" UNITS

Foster Wheeler is now finishing the construction of a 20,000 barrel per day Fluid Catalytic unit for the Shell Oil Company at Houston, Texas. The desired catalyst flow in this unit is obtained by a combination of the static-head pressure in the catalyst stand-pipe and the carrying of a higher pressure in regenerator. Such design reduces regenerator diameter, height of catalyst stand-pipe and risers and height of structural steel required to support regenerator. The savings in materials and construction costs are obvious and can be applied to units of smaller capacity.

HYPERSORPTION

The announcement by Foster Wheeler of this new Union Oil Company of California process for the separation of light gases and vapors evoked enthusiastic response in both the petroleum and chemical industries. The major portion of this response was concerned with the separation of Ethylene from light gases. A commercial Hypersorption unit is now under construction. (Literature, with comprehensive description of pilot-plant operation is available.)

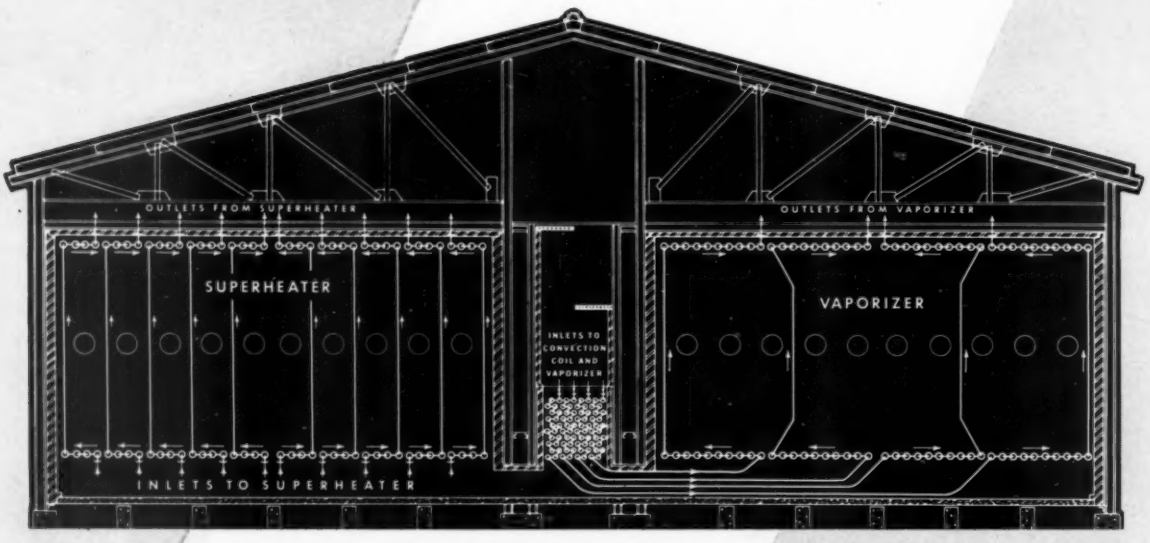
WAX MANUFACTURE BY "REVERSE SEQUENCE"

Oil-free crystalline and micro-crystalline waxes as well as low pour-point lubricating oils are most economically produced by this "reverse" method of dewaxing, which separates the wax first and the oil next, instead of vice versa, as heretofore. (See page 40, Foster Wheeler booklet "Petroleum Refining", available on request.)

Address: Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.

FOSTER WHEELER

"DOWNDRAFT"
OIL HEATERS



14 CONTROLLED COILS IN ONE HEATER

● "DOWNDRAFT" is a patented Foster Wheeler oil heater design in which the gases of combustion from the radiant section of the furnace pass down through screen tubes to the convection section and stack.

Two "DOWNDRAFT" heaters of this type are vaporizing and superheating the charge to two large catalytic cracking units. Design specifications were as follows:

1. A uniform outlet temperature to be maintained for four parallel vaporizer coils and ten superheater coils.
2. Tube wall temperature to be less than 100 deg F. above superheater outlet temperature.
3. Pressure drop in superheater not to exceed 20 psi.
4. Sufficient flexibility to vaporize and superheat four different charging stocks varying in quality from 27.0 to 44.0 API.

"DOWNDRAFT" heater designs, in any capacity, are available for cracking (both thermal and catalytic) atmospheric and vacuum crude distillation and all types of refining heater applications. For further information address:

FOSTER WHEELER CORPORATION
165 Broadway • New York 6, N.Y.

FOSTER WHEELER

Separator Made from Scrap Removes Oil From Exhaust Steam Going to Boiler Feed

By ROY W. MACHEN—Supt., Hammon Oil & Refining Co., Bay City, Texas

THE necessity for using oil separators on exhaust steam lines to remove the oil and purify the exhaust steam before it is condensed for boiler feed water purposes is quite common knowledge. It is also quite definitely recognized to be true that the removal of such oil from exhaust steam before it is admitted to heaters, radiators, dryers, etc. will increase the efficiency of that purified exhaust steam over the efficiency obtainable from the contaminated exhaust steam. This increased efficiency and of course increased production results from the fact that when such oil particles are present in the steam an oily film forms on the inside parts of such heaters, radiators, dryers, etc. and offers in comparison even more heat resistance than an asbestos covering would.

The presence of oil in the condensate used for boiler feed water purposes is recognized to be the direct contributing factor to a great many boiler ills. Minute globules of oil tend to come together and form an oily scum over the surface of the boiler and as the oily particles come in contact with the metal surfaces they stick. When this lodging of oil on the fire sheets and tubes occurs, overheating of the metal at those points of adherence will result with consequent bagging, bulging, weakening of the metal, and often rupture of the materials so covered.

Separator Needed

In order to provide for the needed oil removal from the exhaust steam coming from reciprocating pumps in one of the small refinery "product transfer pump houses" a "home made" separator was made from the available materials at hand. These materials consisted primarily of two short lengths of 36" pipe with ¼" walls, two short pieces of 18" pipe, one 90 degree long radius tube turn, five 6 inch welding neck flanges series 15, one companion flange series 15, and one 6 inch bull plug.

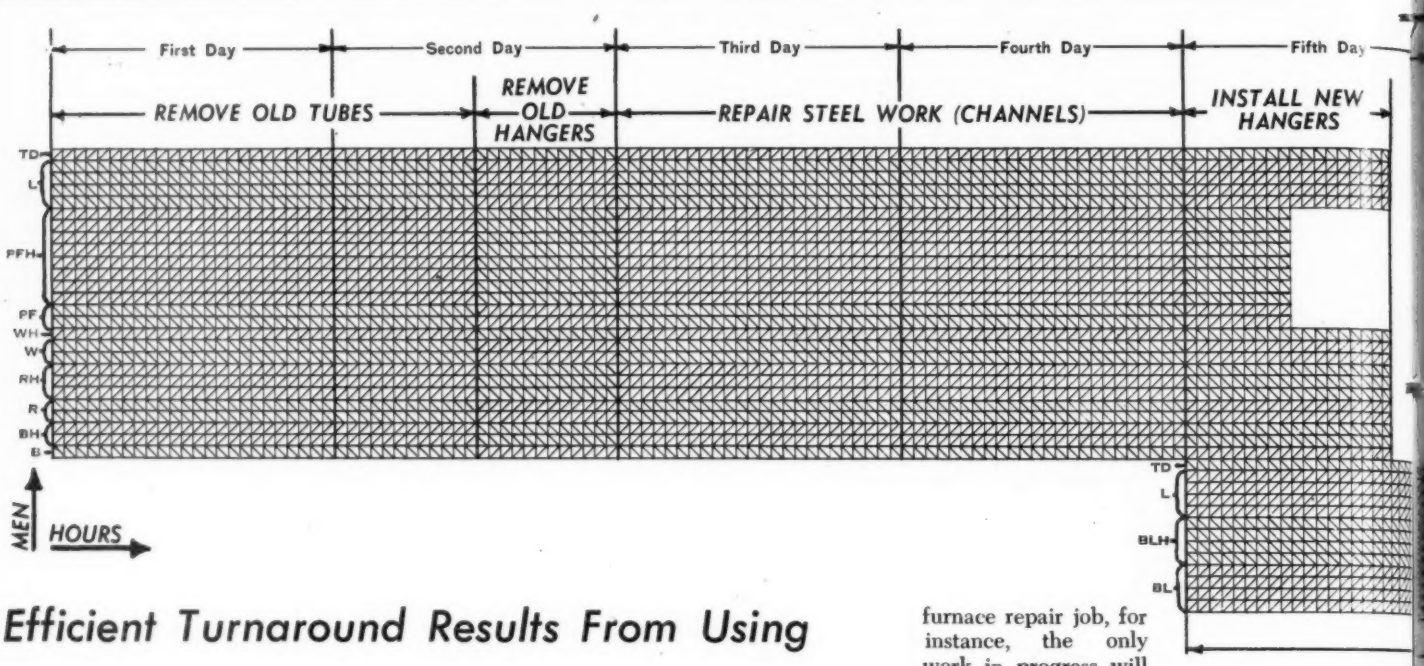
The assembly of these parts can quite readily be ascertained from the accompanying picture. The two lengths of 36 inch pipe were welded together at one end to make one length. This single length of fabricated material was then swadged by notching out, beating down and welding, to take a piece of 18 inch pipe. One of the two pieces of 18 inch pipe mentioned above was welded at the end that was to be the top and it in turn was swadged down to take a six inch long radius tube turn. A six inch welding neck flange was then welded on the open end of the tube turn. On the 36" to 18" swadged portion of the top section of the vessel was located a position for welding in a 6" welding neck flange. After the opening was cut in the vessel to take this connection and it had been welded into place, a piece of ¼" plate was cut to make a blind to fit under the companion flange, which by the way had damaged threads, and after being properly seated with gaskets gave a positive shut off. This opening was to be used as the filling opening for the introduction of the filter material to be used for oil separation.

At the bottom end of the vessel, as has been indicated above, the 36" material was swadged to 18" size and the other piece of 18" pipe welded to it. Before swadging the 18" pipe a plate was welded inside this pipe near to the place of welding to the vessel shell proper. This plate was perforated with numerous small holes sufficient in number and area to accommodate the volume of oil and condensate that had to be handled. After this perforated plate was welded in place, the 18" pipe was swadged in the same manner as had been the top section to a 6 inch sizing and to this was welded a six inch welding neck flange series 15. A welding neck flange series 15 fitted with a bull plug 6 inches in size was then made. This "flanged bull plug" was provided with a 1 inch coupling. On the side of the vessel and just above the point of swadging of the lower portion 36" to 18" was provided an opening to take a six inch welding neck flange. This opening was to be the inlet for the exhaust steam. The vessel was then connected into the existing exhaust steam piping, the outlet coming out the top of the vessel and by means of an 180 degree turn back down and into the existing line to the exhaust steam condenser and from thence to the condensate receiver.

Closeup of the steam oil separator. The outlet is at the top of the vessel and the 180° turn back takes the steam into the exhaust steam condenser and then to the condensate receiver

The vessel was filled with silver grey coke, the plate welded inside the 18 inch nipple on the bottom section acting as a retainer to keep the coke from falling down into the lower section provided by the 18" x 6" swadge and 6" flanged bull plug. The six inch welding flange that had been welded onto the side of the vessel to act as inlet connection had been welded directly to the shell, the shell falling inside of the flange opening having been slotted for steam passage, but in such a manner as to provide for the retention of the coke filter bed. When the vessel had been filled with coke, the "blind" was put in place and secured by gaskets and the companion flange. A short nipple with a shut off valve was screwed into the 1" coupling on the six inch flanged plug at the bottom and the vessel was ready for use. A length of pipe was inserted in the 1" valve to carry the waste that was to be drained off by means of this connection to the sewer.

In operation this coke filtering type oil separator operated quite efficiently. There has been never more than a slight trace of oil in the condensate coming from this source. The coke seems to be self cleaning as the oil and condensate formed in the separator drain down through the section provided below the retaining plate and is bled off by means of the 1" valve and short line provided. The separator has been in service for approximately two years and no addition of filtering medium has been found necessary.



Efficient Turnaround Results From Using Graphical Method to Allocate Man-Hours

EVERYONE has their own pet schemes for allocating manpower and jobs on a unit at scheduled turnaround time to get the work done in the most efficient possible manner and the least amount of elapsed time. Eastern States Petroleum Co., Inc., Houston, uses a graphical method which shows at a glance the number of men of different crafts required on a job and is based on long-time experience of the engineering and mechanical departments. It has the additional advantage of indicating how many men of an individual craft will be at work at a given time, what they are doing and whether or not they are on schedule.

The method involves construction of a graph or chart in which men are plotted as ordinate against hours as abscissa. Superimposed on the time axis are the jobs in progress at any given time during the period of maintenance.

In practice, the repair schedule of a given unit is broken down into any number of convenient parts, each part being scheduled in detail as indicated in the accompanying illustration for an upshot furnace repair. Every other repair job on the unit of which this furnace is part is similarly scheduled. If desired, a master chart embodying the same idea but necessarily with less detail may be drawn for the entire unit. Knowing in advance when a given man—or craft—will be through, the supervisor can tell just when they will be available for other work.

On the first day and a half of the furnace repair job, for instance, the only work in progress will be removal of old tubes. This requires the services of three shifts of 26 men each; a boilermaker and two helpers, two riggers and three helpers, two welders and a helper, two pipefitters and eight helpers, four laborers and a truckdriver. Estimated time for removal of old tubes is 36 hours; on this basis the job will require 936 man-hours.

The old hangars will be removed by the end of the second day, a 12-hour job for these 26 men. Repairing the steel work (channels) will take two days for the same 26-man line-up, and require 1248 man-hours. Installing new hangars will take only 18 hours and the full 26-man gang will not be needed all of this time (nine men for ten hours, 16 men for 18 hours, or 378 man-hours total).

Simultaneously with installation of new hangars, brickwork repair will start. Installing new tubes overlaps in time with brickwork repair and installation of headers; rolling in tubes finishes the job on the tenth day. All told, 6248 man-hours are needed for this particular turnaround, averaging approximately 26.2 for nearly ten days. But this simple average fails to tell the real story, as Table 1 indicates partially, since for a period of four hours there actually are

TABLE 1—Labor Requirements for Upshot Furnace Repair

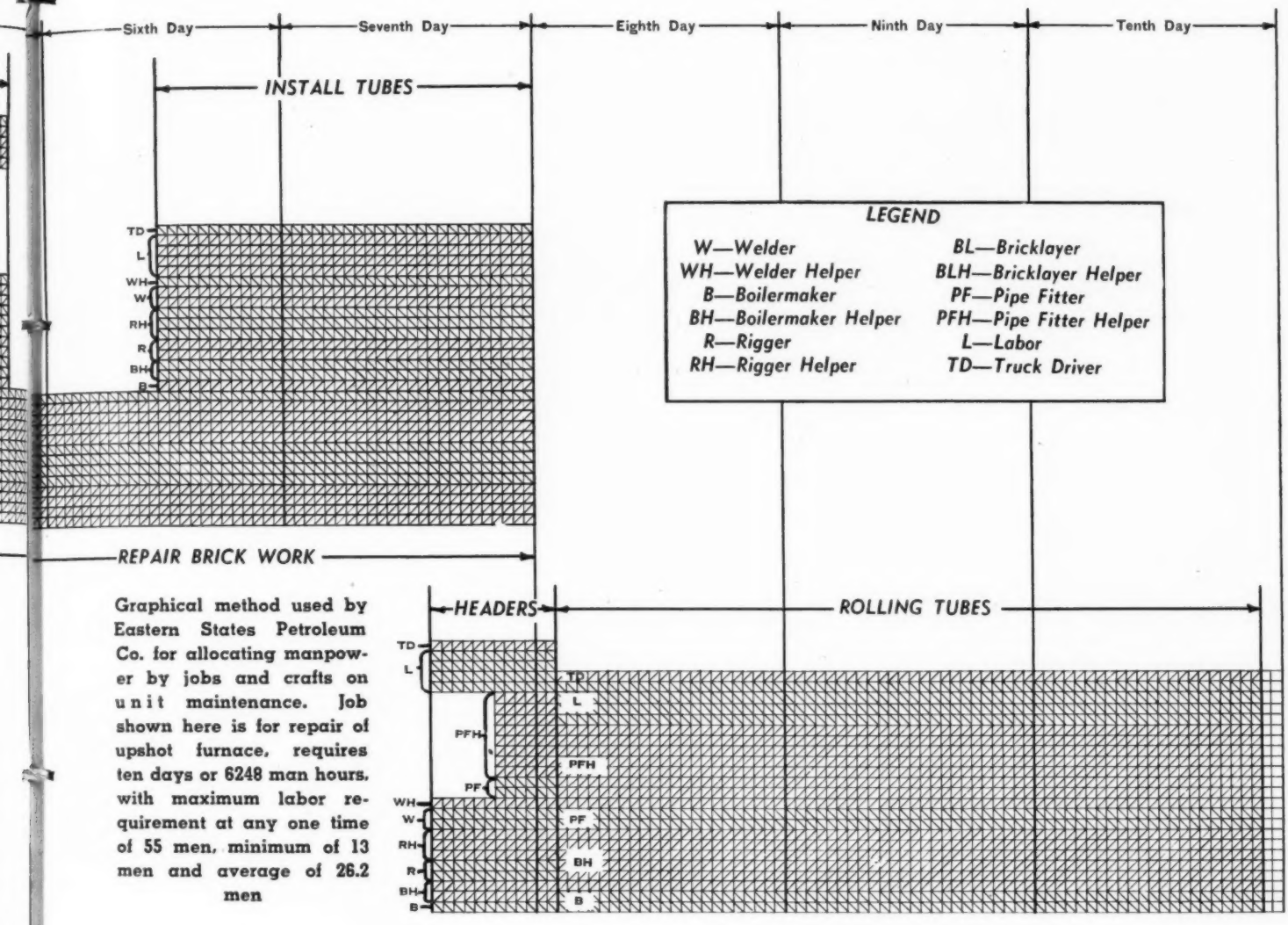
Job Name	Gross Men	Manpower Hours	Man-hours
Remove old tubes	26	36	936
Remove old hangars	26	12	312
Repair steel work (channels)	26	48	1248
Install new hangars	16	18	288
	10	9	90
Repair brickwork	13	72	936
Install tubes	16	36	576
Install headers	16	12	192
	10	6	60
Rolling tubes	23	70	1610
			6248

Wanted—IDEAS!

Plant operators, foremen and superintendents are invited to send in their own contributions of "how we do it around our refinery". Possible subjects could include maintenance and repairs ideas, inspection procedures, operating shortcuts — anything which has made your refinery more efficient and easier to run. Include photographs, drawings or sketches, if available.

Material accepted for publication will be paid for at our regular space rates. Contributions should be addressed to:

Plant Practices Editor
Petroleum Processing
1213 West Third Street
Cleveland 13, Ohio.



Graphical method used by Eastern States Petroleum Co. for allocating manpower by jobs and crafts on unit maintenance. Job shown here is for repair of upshot furnace, requires ten days or 6248 man hours, with maximum labor requirement at any one time of 55 men, minimum of 13 men and average of 26.2 men

55 men at work and for 18 hours there are as few as 13 working; neither does it indicate the breakdown of crafts required.

As an example of how this scheduling works out in practice, recently an alkylation unit at this plant was scheduled for routine maintenance. Schedules of each major job, similar to the axample discussed above, were drawn up in advance on the basis of inspection records and past experience. When the work was completed, it was found that the estimate differed by only a few hours from the actual time required from the moment repairs started until the job was finished.

Device for Calibrating Pressure Gages Simultaneously Saves Time and Energy

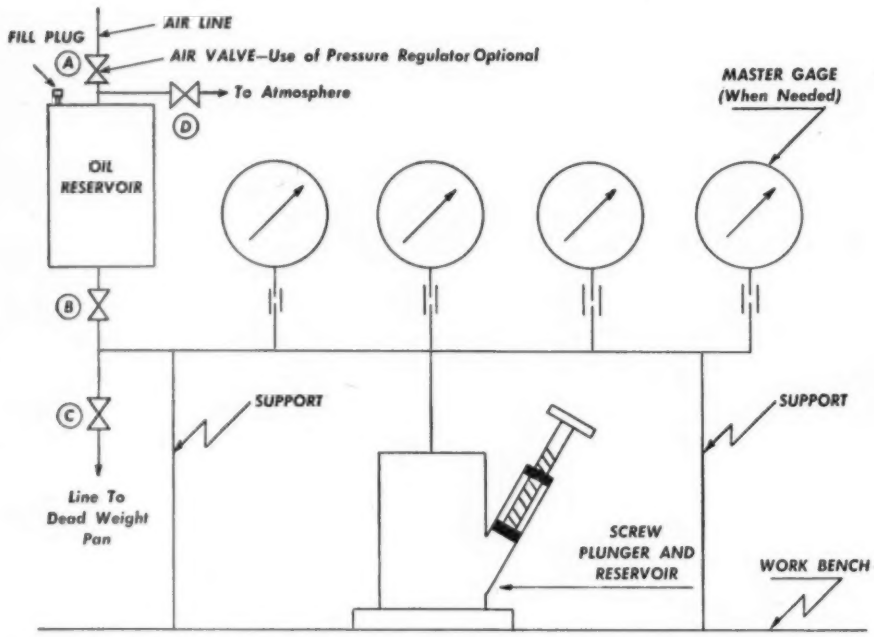
IT IS often necessary around a natural gasoline plant or refinery for a number of pressure gages to be tested and calibrated at the same pressure. A manifold has been devised by one of the Humble Oil & Refining Co.'s plants which permits the simultaneous testing of several gages. The use of oil under air pressure to load the gages eliminates loading with the conventional hand-operated tester. A standard test set is incorporated in the hook-up to permit calibration by the dead-weight method when desired.

Supported on a work bench, above a fabricated manifold of small diameter pipe and fittings, is an oil reservoir which may be a piece of large diameter pipe or any convenient container capable of withstanding maximum pressure from the air supply line. At the top of the reservoir are the connection to the air supply and the filler-hole, usually closed by a plug. An ordinary valve may be used in the air-supply line or a pressure regulator may be substituted if desired. (Use of a regulator is recommended as it may be set to prevent overrunning the gage or it may be set for two or three point calibrations). A vent valve for de-pressuring the reservoir should also be installed. The connection to the manifold is at the bottom of the oil reservoir.

Connections for three or more gages are provided in the manifold, also a connection to a conventional deadweight pan and screw-type reservoir for deadweight calibration when desired. A master-gage can be mounted on the manifold, or it may be incorporated in the pressure regulator if one is used.

Several gages to be tested are mounted on the manifold, unneeded connections being capped off, valves "A," "C" and "D" being closed while "B" is open. Oil is pressured by opening valve "A," which may be either a common valve or a pressure regulator. Pressure is adjusted to the desired point for calibration by cracking valve "D," if valve "A" is not a pressure regulator.

After calibration is completed, "A" is closed and valve "D" is opened to vent



Schematic diagram of device for simultaneous calibration of several pressure gages, incorporating loading gages by air-pressure from plant supply-line

the reservoir. Optionally, valve "B" may be closed, which avoids venting the reservoir to atmosphere, but "B" *must* be closed before gages are removed.

The air-pressure loading of gages for calibration does not interfere with testing by the deadweight method. For deadweight calibration, valve "B" is closed and valve "C" opened. Pan is loaded in the normal manner with standard weights and gages loaded with the usual screw plunger.

the clamps, and the center-plate drawn towards the crank-end to stretch the spring to its original length. This length is held until the spring cools, whence it is ready for reinstallation. Cost of stretching is approximately $2 per dozen.

Idea Questioned

At first there was some question among technical personnel about the value of the idea—entered for a job-suggestion award—on the grounds that the heating and subsequent uncontrolled air-cooling would destroy the temper of the spring and that it would quickly fail in service. However, re-stretched springs have been in service for periods exceeding eight months without a single failure.

Restretching springs is now regular practice at the company's gasoline plants, which send their springs into a single plant where the stretcher is located. It is regarded as simpler and cheaper to use "central-station" technique rather than build a stretcher for each plant.

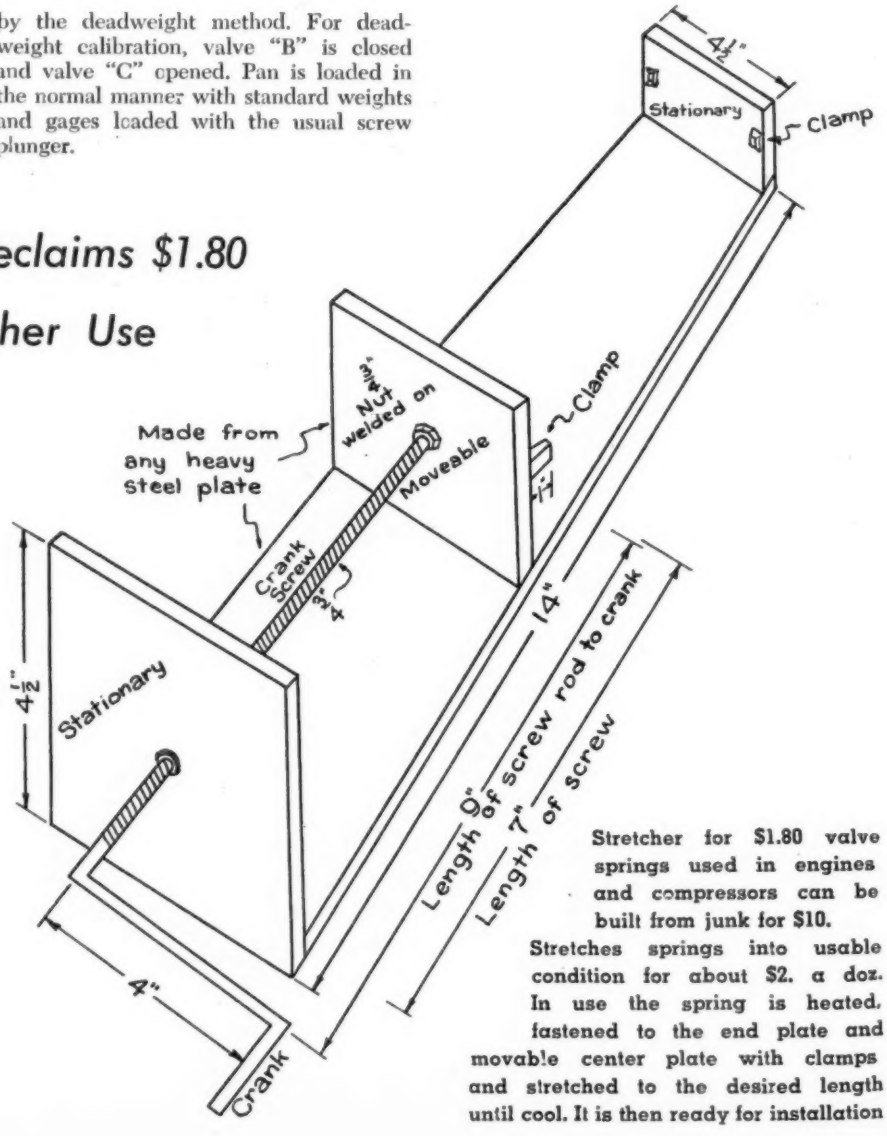
Homemade Stretcher Reclaims $1.80 Valve Springs for Further Use

VALVE springs become set after several months use, due to the heat conducted to them while the engine or compressor is running, and because they are constantly under at least some compression. In the past, when they became set it has been customary to throw them away, but F. G. Fisher, an operator at one of Cities Service Oil Co.'s gasoline plants, decided these springs, which cost $1.80 new, could be re-stretched and used again by means of the spring stretcher shown in the drawing.

Cost About $10.00

The stretcher was made out of four pieces of heavy steel plate, a pair of clamps and a crank screw. The stretcher was fabricated by welding so that the center plate is movable and attached to the crank screw, while the two end pieces are stationary. Cost of building the machine, exclusive of materials, was about $10.

In use, the spring is heated sufficiently to prevent its breaking during stretching, attached to the end- and center-plates by

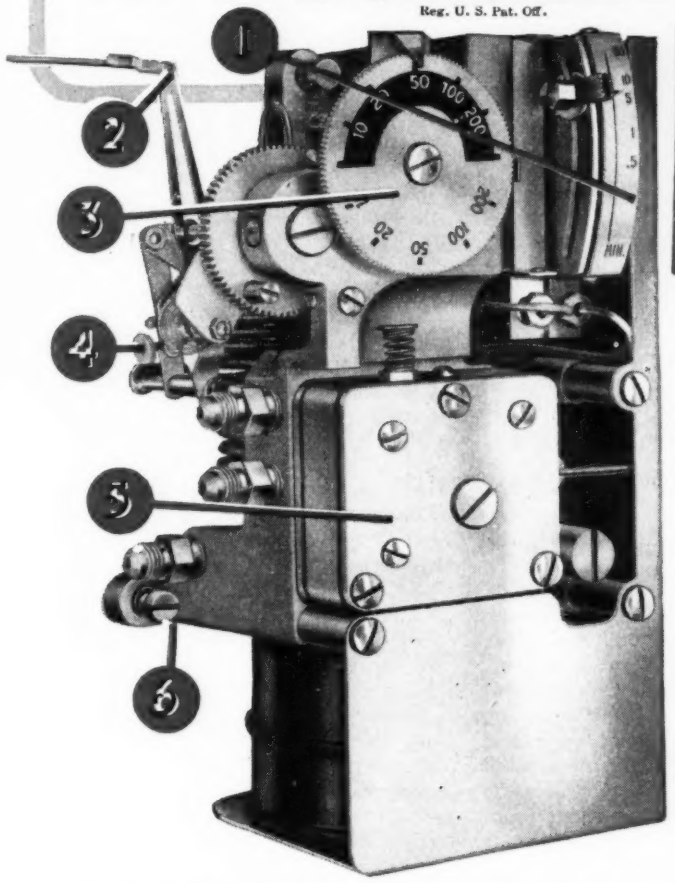


Stretcher for $1.80 valve springs used in engines and compressors can be built from junk for $10. Stretches springs into usable condition for about $2. a doz. In use the spring is heated, fastened to the end plate and movable center plate with clamps and stretched to the desired length until cool. It is then ready for installation

Look Here...

FOR THE BIGGEST NEWS ABOUT FOXBORO'S M-40 CONTROLLER

Reg. U. S. Pat. Off.



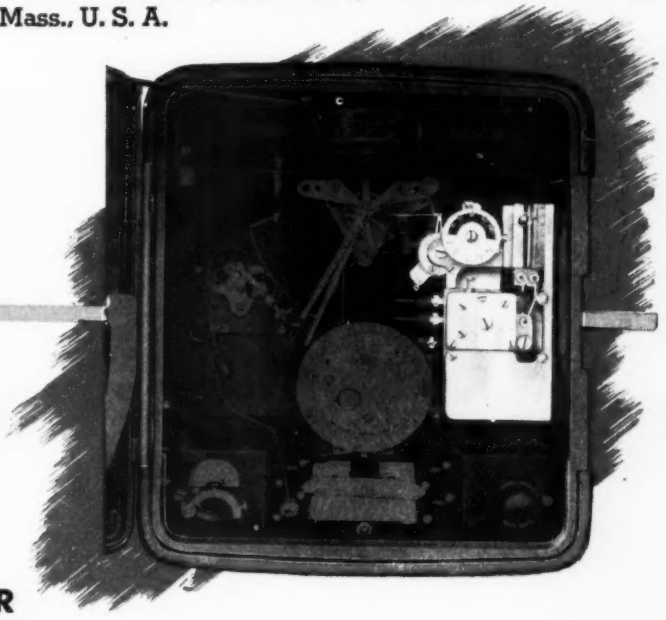
A COMPLETELY REDESIGNED CONTROL UNIT

THE M-40 Control Unit is new inside and out. With all its added ruggedness, it has a supersensitivity usually associated only with laboratory instruments. Accurate adjustments are much easier to make, and cover a greatly increased range. Once they're set they stay "on the beam". Maintenance is minimized – and very much simpler. Sub-assemblies can be removed and replaced without loss of original alignment.

Advantages like these are the direct result of over thirty-five years of pioneering research and experience in the development and production of industrial instruments.

If your own process involves the control of Temperature, Pressure, Flow, Liquid Level, Humidity, Density, Speed or Motion, look up the detailed facts on this better-engineered control unit. Write for Bulletin 381, **The Foxboro Company, 56 Neponset Avenue, Foxboro, Mass., U. S. A.**

1. **New Reset Unit.** Continuously variable reset resistance obtained without use of needle valves or lengths of capillary tubing. Time constants between 0.1 and 50 minutes set by simple lever. Rate-sensitive (Hyper-Reset) value is set by similar lever, coordinated for identical, simultaneous adjustment by operator.
2. **New Ball Bearing Linkage.** Operates essentially like universal joint. Unique ball contact permits free lateral movement without backlash or binding. Made to extremely close tolerances.
3. **New Proportional Band Setting.** 0 to 200%, either direct or reverse action, is made by simple turn of a dial. No removing or changing of parts.
4. **Only One Field Alignment.**
5. **New Control Relay;** simple design with ability to withstand overload up to 50 psi. Can be removed, inspected, or cleaned and quickly reassembled, without affecting initial adjustment.
6. **Entire Unit** easily removed by disconnecting one link, three air connections and removing three retained screws.



THE NEW

FOXBORO
Reg. U. S. Pat. Off.

M-40

CONTROLLER

The Only Controller with *Permaligned* Construction

Preventing the Fouling of Cooling Waters Reduces Plant's Waste Disposal Costs

Article 10 in a Series—By W. B. HART

In Charge of Waste Disposal for Atlantic Refining Co.

An early and important step in planning an effective waste disposal program is to adopt means for the prevention, if possible, of the contamination of plant waters. The disposal of uncontaminated wastes is a relatively simple matter.

A practical example of such prevention methods is the installation of double discharge lines for water from tubular cooling equipment, so that waste contaminated by leaking oil can be diverted to the line leading to the waste treating plant. Methods are also given for protecting from contamination the waste water from a coil cooler.

WASTE waters are often regarded as uncontaminated because they are free of oil or other substances commonly thought of in connection with water pollution. However, these so-called "uncontaminated" waste waters may affect the temperature, dissolved oxygen content, biochemical oxygen demand, or even the toxicity of surface waters into which they are discharged. Of these effects, the two most likely to occur are those upon temperature and those upon the dissolved oxygen content. Because of these and other possible effects which may result from abnormal operation, the so-called uncontaminated waste waters may require treatment prior to disposal.

Before describing treatment methods, some mention should be made of the rather prevalent idea that if the waters do not contact oil, in normal use, the resulting waste is always uncontaminated and can be disposed of without any particular attention. This idea is wrong, for there are usually a number of possibilities of contamination, such as leaks in tubular coolers, spills to sewer inlets, and similar accidents. But reasonable precautionary measures can be taken to avoid such accidental contamination, although it is unlikely that every hazard can be covered in a practicable manner.

The economy which will result from maintaining as much waste as possible in an uncontaminated condition will be obvious. Under some conditions such waste can be disposed of without any treatment at all. If treatment is required, it will be simple and inexpensive in both first cost and operation. Therefore, great importance attaches to methods which will prevent contamination.

These methods are matters of both operating conditions and design. Most of the water used in a refinery is cooling water, therefore cooling equipment should be considered first. Tubular equipment presents what is probably the major phase of the cooling water problem.

Two Conditions in Tubes

In the use of tubular equipment two conditions occur. If the cooling water is under greater pressure than the oil in the equipment, and tube leaks occur, the water will leak into the oil stream and the waste leaving the cooling equipment will not be contaminated. Such waste can be collected and disposed of directly unless treatment to correct temperature or other features is necessary.

But if the oil is under greater pressure than that on the water and leakage occurs, the oil will pass into the water. The water leaving the equipment then will be contaminated with oil. If disposal directly to surface waters continues unchecked, it may cause serious pollution.

This condition can be overcome in several ways, depending upon the design of the refinery drainage system. If a single drainage system with proper treatment facilities is used, for all waste discharge, the oil from the leaking equipment will be retained, and pollution will not occur. If a double drainage system is employed. with a separate sewer system for uncontaminated waste, a directional discharge arrangement can be used. In this arrangement there will be two water discharge lines from each piece of tubular equipment which can cause pollution. Each line of one set of discharge lines should be equipped with an open sampling device, as shown in Fig. 1, or other means by which any oil leaking into the water can be detected quickly. These discharge lines then are connected to a "header", which in turn discharges to the uncontaminated waste water sewer system. The other discharge lines are connected to a "header" which discharges in turn to the contaminated sewer system, or to an individual waste treatment plant.

Uses "Look Box"

In normal operation the waste water leaving any piece of tubular equipment passes the sampling device or "look box" and on through the uncontaminated disposal system. Should a leak occur in any tubular cooler the oil will appear in the look-box, and the discharge flow can be diverted promptly to the other line leading to the treatment plant. Some operators may be apprehensive of serious pollution resulting from such an arrangement. Experience has shown, however, that only rarely do leaks occur which abruptly release large quantities of oil. Instead, the leaks are usually quite small at first, and will make themselves known by small globules of oil appearing in the sampling device.

The advantages of this arrangement, are first, the individual waste treatment plant can be smaller and less costly, for it can be constructed to handle the waste from only a fraction of the total number of coolers for which the system is applicable (it is unlikely that several well maintained coolers will be leaking at the same time); second, if any one or two tubular units must be turned to an existing waste treatment plant, the load on the plant will not be increased very greatly, and its effectiveness will not be impaired. It must be assumed that the oil detection device will be examined frequently, and that the possibility of leakage will not be ignored. The system is diagrammed in Fig. 2.

It is sometimes desirable to hold a reserve of water near a still for emergency use in case of failure of the normal supply, and to permit emergency shut-down without a fire hazard. Use can also be made of this tank to retain the water, which may become contaminated as a result of leakage in the still coils. A special run-off arrangement for the water is

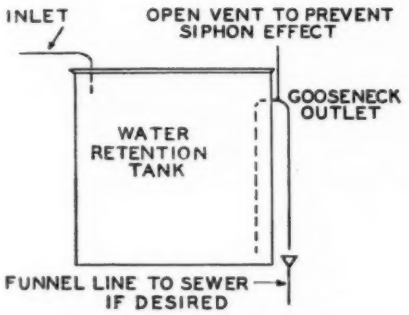


Fig. 3—Diagram of emergency water tank used also as a waste treatment plant

necessary and is illustrated in Fig. 3. Single discharge lines from each cooling unit can be used in this arrangement. Thus the tank serves as a detector of escaping oil and as a waste treatment plant, as well as a reserve water supply.

Any one of the above methods for handling normal wastes which may be contaminated occasionally through leakage can be adapted to existing equipment or designed into new equipment. The choice will depend upon local conditions, economics, and the requirements of regulatory agencies. For example, in the second scheme the cost of an increase in piping and valves is offset by their smaller size and by less expensive waste treatment plant needs. If operated with reasonable care, and the oil detection equipment is watched, it will prove satisfactory under a variety of circumstances.

The third scheme provides perhaps greater assurance against pollution, but only at the cost of a large tank and some special piping. Also, when leakage does occur, although the collection of oil in the tank reveals it, there is no way of knowing just what cooler is involved.

The first method described requires only a single system of lines for collection of all waste, regardless of pressure relationships within the coolers, but it also requires individual waste treatment equipment of sufficient size for all the waste, or additional capacity in plant treatment facilities. Although this may be quite costly, it may be necessary where the escape of even relatively minute quantities of oil must be prevented.

Protection For Coil Coolers

Tars and various residual products are often cooled in a coil of pipe submerged in water, known as a "coil cooler" or "box cooler." The cooling water enters the box at one end and by baffles or simple current effects passes upward around the coil and over a weir to the discharge line leading to the sewer. This waste can be protected from contamination rather easily, so that it can be directed to the uncontaminated drainage system.

The necessary protection can be provided by installing an oil retention baffle or a submerged outlet. The fundamental idea in either instance is to carry the water away from below any oil which may escape from a leaky coil and to hold back the oil for collection and removal. This is the arrangement for oils which, at the temperature of the water, are lighter than the water. In the few cases where the oil is heavier than the water the same arrangement should be used rather than the reverse, as some operators may think to be necessary. The reason is that if the oil is heavier than water at the water temperature it will sink to the bottom of the box and be retained. If the temperature falls the oil will be still heavier, but if the temperature rises the oil may become less dense and consequently float. Then, unless there is a retaining baffle, the oil will escape. However, a submerged outlet should never be used when there is any chance that the oil will be constantly heavier than the water. The various arrangements are shown in Figures 4 and 5.

Treatment Methods

The economy which will result if as much waste as possible is protected from contamination will become especially apparent in the discussion of treatment methods. These methods are designed to correct, where necessary, the temperature, the dissolved oxygen content, and the toxicity of the waste. The extent to which the correction must be carried is a matter of judgment, which can

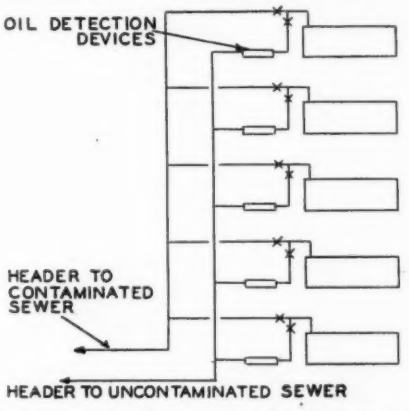


Fig. 2—Piping scheme for series of coolers for oil detection and diversion system

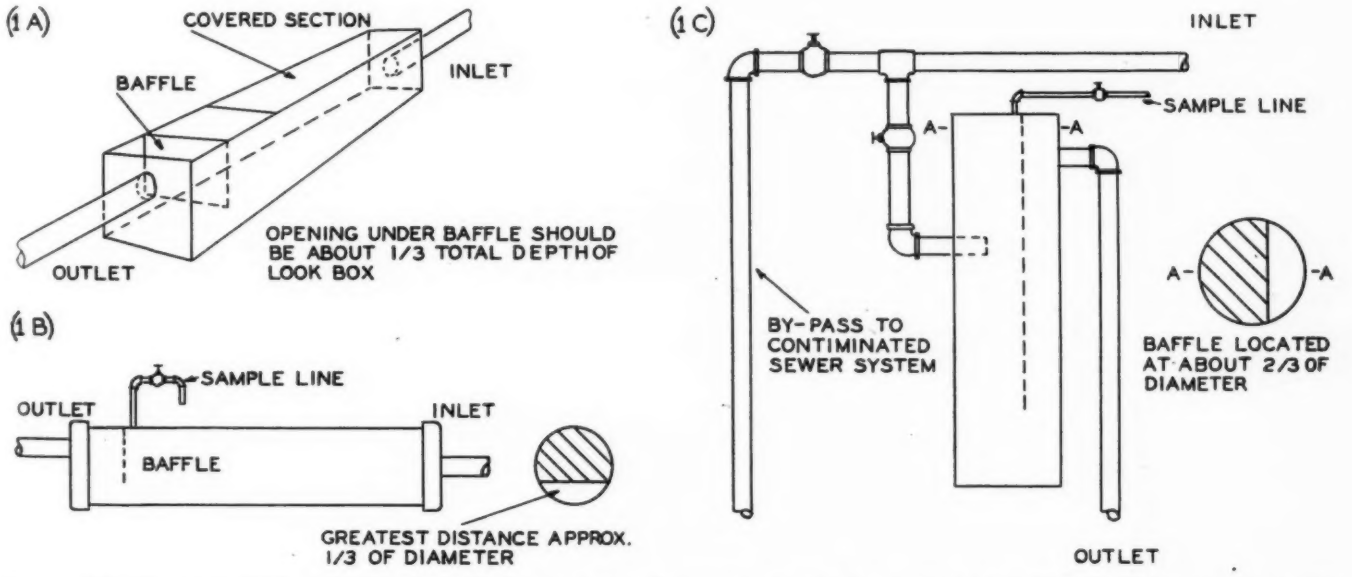
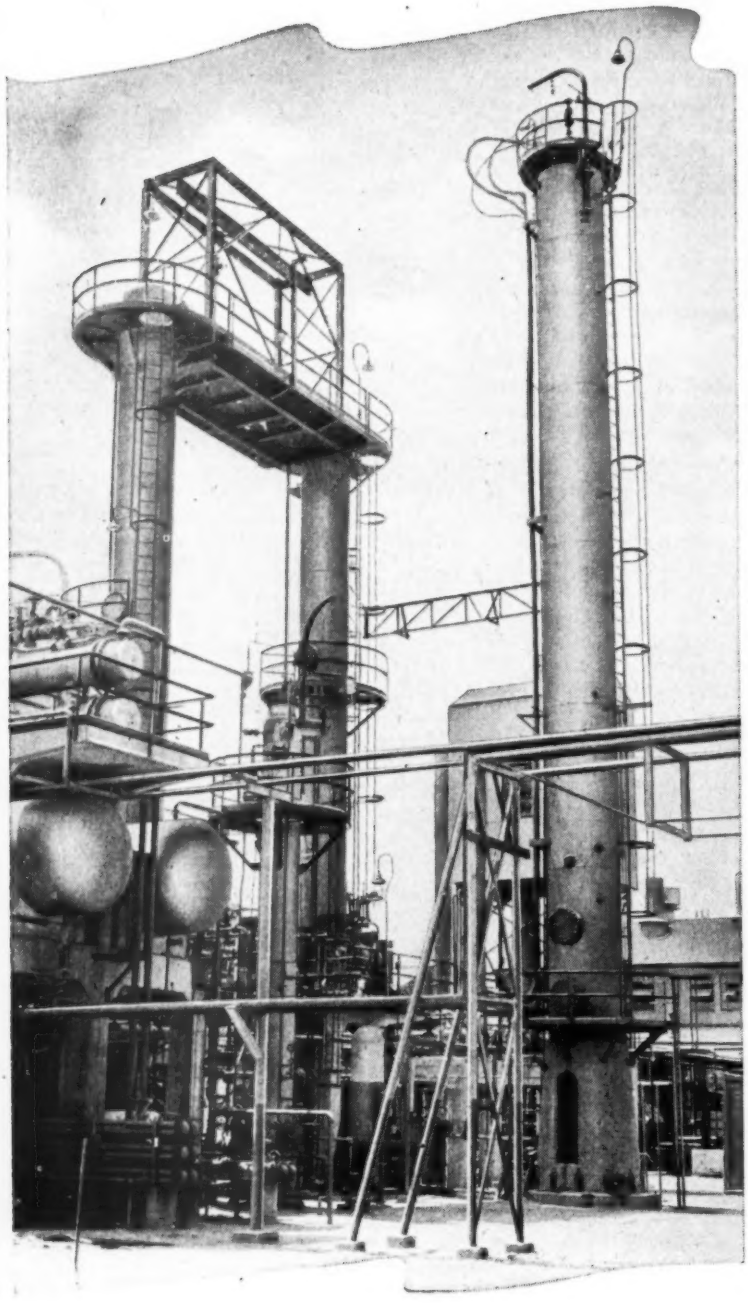


Fig. 1—Oil Detection Devices. 1A. (Top left) is one form of open look box for detecting oil in waste from tubular equipment. The device retains only sufficient oil to show that oil is present. Various piping arrangements are possible, but the outlet should always be located well above the bottom of the baffle. 1B. (Bottom left) closed form or device. Sample to be taken frequently and examined for oil. Size is comparable to open type shown above. 1C. (Right), a vertical form of closed type detection device

FRONTIER MAKES A QUICK CONVERSION FOR

Increased Yield - Higher Octane



Gasoline production increased by 5 to 6%. Production of 150 to 200 bbls. per day of 82½ octane polymer with a blending value of 100. That's a quick picture of the operation of Frontier Refining Company's new polymerization unit at the Cheyenne Refinery.

But that's only part of the story. This unit was converted from an isomerization unit, operated by the refinery during the war in production of high octane aviation gasoline components. After the war Frontier had to consider how this equipment could be used effectively in producing for a peace time market. An analysis by UOP engineers indicated that this unit could be economically converted into a non-selective catalytic polymerization unit. Most of the existing equipment was utilized and a relatively small investment in new equipment was required. The results speak for themselves.

This is a typical example of the application of UOP research, engineering, processes, and service to a specific refinery problem. A four way technique that is helping refineries all over the world find a profitable solution to the strict demands of their present day operations.

UNIVERSAL OIL PRODUCTS COMPANY

General Offices: 310 S. MICHIGAN AVE. UOP CHICAGO 4, ILLINOIS, U. S. A.

LABORATORIES: RIVERSIDE, ILLINOIS

UNIVERSAL SERVICE PROTECTS YOUR REFINERY

be based upon the description of the effects of wastes, discussed earlier in this series. The effects of any particular waste should always be considered carefully before deciding upon the design of a treatment plant or the extent of treatment which will be necessary.

In considering toxicity, the first question to be answered is whether it is present in any form, and if so, to what extent. If present, it will usually be in the form of metallic ions resulting from corrosion. Metals in insoluble form are of little consequence unless present in quantity which presents a turbidity or a shoaling problem over a number of years. These conditions rarely, if ever, will be encountered.

The quantity and quality of surface water and the relation of these factors to the quantity of waste and concentration of metallic ions should be determined next. Unless the receiving water is very "soft" and its volume low, the metallic ions in the waste will usually be precipitated by the bicarbonates naturally present in the water. Then there will be no problem. But it should be established clearly by analyses of both the waste and the receiving water that there will be precipitation of the metallic ions by the alkalinity of the surface waters without materially reducing this alkalinity.

When the surface water is "hard", there is every likelihood that complete precipitation will occur without harm to the water or its uses, or to the aquatic life it supports. But in any event, the surface water in the region which the waste discharge can affect should be sampled, and the samples analyzed to be sure there are no harmful results.

Use Fish for Toxicity Test

The absence of toxicity should be clearly established by standardized tests. Fish can be used as test animals [138]. If these tests reveal that some form of toxicity is present, then each flow which contributes to the main flow of waste should be fully surveyed and the source of the toxicity located. The offending flow or flows can then be diverted to some other treatment plant which will be effective. Treatment methods will be considered later.

Because cooling water represents the chief waste which may be regarded for present purposes as uncontaminated, its temperature is probably the most important factor. This importance, however, will exist only if there is not enough receiving water to cool the waste by admixture. Here again if will be necessary to know the volume and the maximum temperature likely to occur in the surface water. Lake currents should be given careful attention in this connection.

Sometimes, when the low flow of surface water is greatly in excess of the flow of waste, a mere weighted averag-

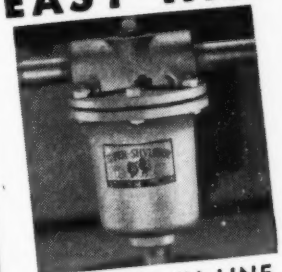
WHEN
regular steam traps
WON'T DO

Use Anderson specific purpose traps for installations where a regular trap won't do. For example—on higher pressures and temperatures use the Steel Series Super-Silvertop; for air elimination even when pressures drop (as overnight) to as little as a fraction of an ounce, use the Super-Silvertop series "B" traps; for handling large volumes of air, call for Thermal Air Eliminator equipped Super-Silvertops.

Whatever your needs may be, there's a Super-Silvertop that fills the requirements. Find out more about these Anderson steam traps —write today for your *copy* of "How To Choose a Steam Trap".

THE V. D. ANDERSON COMPANY
1974 WEST 96th STREET • CLEVELAND 2, OHIO

Do it the EASY WAY



STRAIGHT- IN-LINE

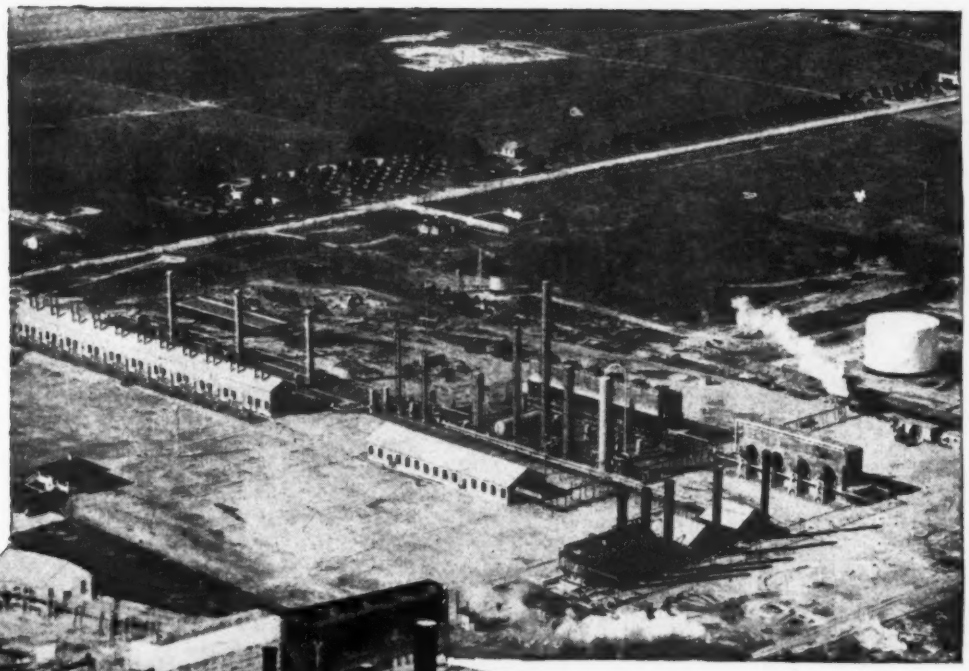
AS AN ELBOW

SUPER-SILVERTOP STEAM TRAPS

THE NEW
La Gloria

300 million cubic feet daily...
50 per cent propane recovery

The approximate daily gas capacity of this plant was increased from 150 million to 300 million cubic feet in successive plant expansions, the original plant and all of the additions being designed and installed by HUDSON. In each expansion, revised process design was employed to allow maximum use of previously installed equipment, thus minimizing the expense of the additions.



A view of the original plant finished in 1941.

An aerial view of the plant as it appears today after four major expansions.

THE HUDSON organization, qualified by years of experience in the successful design, construction and operation of major hydrocarbon processing plants, offers its specialized services for projects in any part of the world.

GAS COMPRESSOR STATIONS • CYCLING PLANTS • GAS DEHYDRATION PLANTS • NATURAL GASOLINE PLANTS • FRACTIONATION UNITS • CRUDE TOPPING UNITS • PRESSURE MAINTENANCE PLANTS HYDROGEN SULPHIDE REMOVAL PLANTS • ATMOSPHERIC AND VACUUM DISTILLATION UNITS

HUDSON
ENGINEERING CORPORATION

Engineers and Constructors

FAIRVIEW STATION • HOUSTON, TEXAS

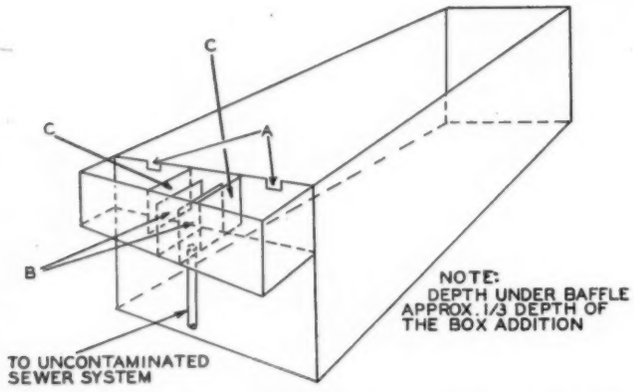
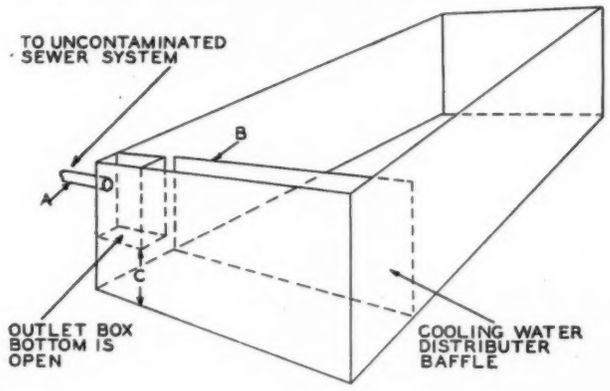


Fig. 4—(Above) An oil retention box system for addition to a cooler coil box. The crests of weirs A and B should be at the same elevation, so that the entire box surface will serve as a reservoir for the oil layer. The oil retention baffles are denoted by C.

Fig. 5—(Below) Arrangement for preventing contamination of cooler box waste. Elevation of outlet pipe A and crest of baffle B should be approximately the same. Height C should be approximately one-third the depth of the cooler box



ing of temperatures will show conclusively that the waste is not causing serious temperature increases. Then, no further attention is required, particularly if the average temperature does not exceed about 85° F. A lower maximum temperature may be required in special cases.

When the natural flow is low, however, some cooling of the waste prior to discharge may be necessary. Or, it may be economical to reuse the water after cooling, instead of wasting it. If this is not done, and some form of cooling must be employed, a back and forth system of troughs will be the best equipment. Given sufficient hydraulic gradient, weirs may be added to produce free fall in a series of steps, providing not only cooling but also aeration.

The only specification which need be placed upon the troughs is that they be shallow, have low side walls, be provided with mixing baffles, and be so located that they will get the effect of any wind action. Since this procedure will be necessary only when the waste is unusually warm, the temperature differential between waste and air will be rather large. A cooling effect of several degrees can be obtained from 200 or 300 ft. of trough flow if the flow velocity is not excessive.

Temperature Affects Oxygen

Uncontaminated wastes rarely contain substances which consume dissolved oxygen in concentrations which present a problem. And they usually contain little or no dissolved oxygen. This, however, is the result of their elevated temperature and its influence upon the solubility of oxygen. Consequently, if it is necessary to treat the waste before discharge to assure that it will not depress the dissolved oxygen content of the receiving waters, it is necessary only to introduce air.

This can be accomplished in several ways. If a cooling channel is used and is constructed for shallow flow with a wide water surface, enough oxygen will usually be absorbed as the waste flows through the channel. If there are weirs in the channel, or other structures producing cascade effects, sufficient dissolved oxygen is pretty well assured. Even the spilling effect which usually results at the outfall weir of a separator (to be described later) will often introduce enough oxygen.

The question of what is enough oxygen again brings up the relationship of the waste flow to the surface water flow. By calculating the pounds of oxygen per day available for admixture, and also the oxygen demand or dissolved oxygen in the waste, the resultant dissolved oxygen after admixture can be determined, and if this is not sufficient, the deficiency can be estimated. The accompanying example will clarify this important phase of treatment.

Because of the great importance of dissolved oxygen to surface waters the effectiveness of any scheme for maintaining the dissolved oxygen content of these waters should be checked frequently by surveys of the waters. This is particularly true in the case of lakes where currents may be variable, and at best, not well defined.

References

(138) "The Evaluation of the Toxicity of Industrial Wastes, Chemicals, and other Substances to Fresh-Water Fishes." W. Bregy Hart, Peter Doudoroff, and John Greenbank. The Atlantic Refining Company (Waste Control Laboratory), Philadelphia. 317 pp. 1945.

Example—Calculation of Dissolved Oxygen after Admixture of Waste Waters

Assume that the rate of discharge for waste water is 2 million gals/day, and that it has an oxygen demand of 3 p.p.m. Surface water base flow is 500 million gals/day, and its minimum dissolved oxygen content is 5.5 p.p.m. (Base flow is the minimum flow of record.)

Then:

25 million gals x 7.5 lbs. = 187.5 mllion lbs./day of waste
187.5 x 3 p.p.m. = 562.5 lbs. of oxygen demand.

Also:

500 million gals x 7.5 lbs. = 3750 million lbs./day of flow.
3750 x 5.5 p.p.m. = 20,625 lbs. of dissolved oxygen.

When the waste and the surface water flow are mixed, the effect on the dissolved oxygen can be expressed with sufficient accuracy as:

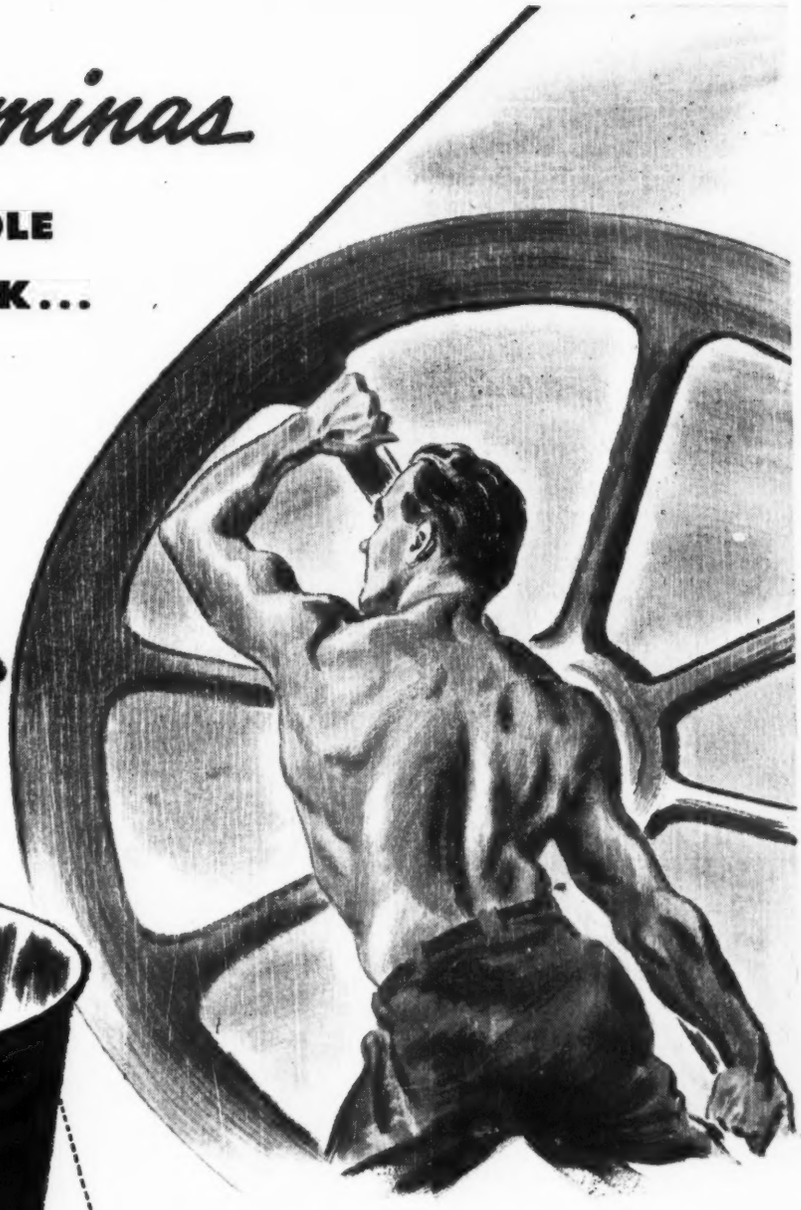
20,625 − 562.5 = 20,062.5 lbs. minimum available dissolved oxygen in
3750 + 187.5 = 3937.5 million lbs. of flow; and the resulting concentration will be:

20,062.5 ÷ 3937.5 = 5.1 p.p.m.

This average dissolved oxygen content is ample as indicated earlier under the discussion of effects. It should be noted that in the above example the waste was assumed to have an oxygen demand. Had there been a dissolved oxygen content, it would have been added rather than subtracted. It should be understood further that there may be present in the waste water both oxygen demand and dissolved oxygen. This can occur because oxygen demand is determined biochemically, requiring bacterial action and time. When both dissolved oxygen and oxygen demand are present, the calculation involves addition of the dissolved oxygen and subtraction of the oxygen demand.

Alorco Aluminas

PLAY A DOUBLE ROLE IN CATALYTIC WORK...



As a Drying Agent

Anhydrous catalysts need moisture-free feedstocks. Otherwise, efficiencies are likely to fall off seriously and reactions may go awry.

Alorco Activated Aluminas provide dependable, low dew point drying for feedstocks, helping to secure maximum production and to keep processes "on the beam". They serve year after year, their drying ability being restored simply by reactivating them by heating.

As Catalysts and Carriers

Alorco Aluminas are serving the petroleum, synthetic rubber, and chemical industries as active and auxiliary catalysts, and as carriers. Their physical properties suit them to long life with continued high productive capacity. They are able to withstand high temperatures.

Because Alorco Aluminas are high in purity and carefully controlled in chemical content, there's less likelihood of side reactions and poisoning.

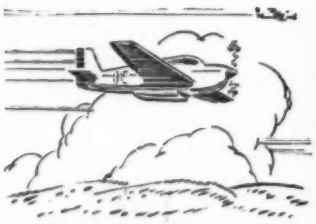
Whether your problem is one of drying or catalysis, it will pay you to investigate the use of Alorco Aluminas. Tell us your needs and we'll advise on the types best suited. Call the nearby Alcoa office, or write ALUMINUM ORE COMPANY, Subsidiary of Aluminum Company of America, 2000 Gulf Building, Pittsburgh 19, Pennsylvania.

ALUMINUM ORE COMPANY

Aluminas and Fluorides

ALORCO

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

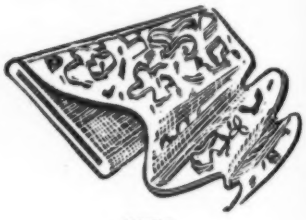


HIGH OCTANE GASOLINE

LUBRICANTS

SYNTHETIC RUBBER

PHARMACEUTICALS



DYES

VARNISHES

How will you have your Aluminum Chloride?

Uniformity is of course your first requisite, and that's what you get from Hooker. Every shipment of Hooker Aluminum Chloride, Anhydrous, is of the same high purity as the previous one. You can count on uniform results in your processes where they depend on uniform purity of the Aluminum Chloride you use.

Is size of importance in your operations? Hooker Aluminum Chloride is available in three different sizes—one of which will surely meet your requirements:

Fine Grind—an unscreened material practically all passing 20 mesh.
Coarse Grind—unscreened, 1 mesh and finer containing 25 to 35% finer than 20 mesh.
Coarse Screened—same as above screened to remove 20 mesh and finer.

Whether you want to use Aluminum Chloride for a catalyst in Friedel-Crafts synthesis, polymerization, isomerization or halogenation, Hooker can supply it in the form best suited for your processes. As a catalyst in the preparation of derivatives for use in the manufacture of high octane gasoline, lubricants, synthetic rubber, dyes, varnishes, pharmaceuticals, etc., Hooker Aluminum Chloride has a freedom from iron and other impurities that insures smooth reactions.

Hooker Data Sheet No. 714, yours for the asking on your company letterhead, gives additional physical and chemical data. Hooker's Technical Staff is also ready to help you with the application of Aluminum Chloride and the other Hooker Chemicals to your particular problems.

HOOKER SPECIFICATION

Aluminum Chloride, Anhydrous, $AlCl_3$

Gray, Crystalline solid

Molecular Weight 133.3

Analysis

Aluminum Chloride . . . . . 98.5 % min.

Iron . . . . . 0.05% max.

Non-sublimables in air at 950°C . . . . . 1.5 % max.

HOOKER ELECTROCHEMICAL COMPANY

4713 BUFFALO AVENUE, NIAGARA FALLS, N.Y.
New York, N.Y. Wilmington, Calif. Tacoma, Wash.

HOOKER CHEMICALS

Caustic Soda
Antimony Trichloride
Muriatic Acid
Chlorine
Sodium Sulfide
Sodium Sulfhydrate

Patent Trends in Petroleum Refining

By Peter J. Gaylor

Patent Attorney and Editor "The Technical Survey"

Recent developments disclosed in patents reviewed below include:

Use of the relationship of melting point and refractive index of sweated wax and sweat stream as a control method in the rapid and economic production of waxes of various oil contents.

Evaporation losses in the storage of volatile liquids reduced by use of live steam.

Production of neopentane as a valuable aviation fuel blending agent.

Wax Sweating

THE sweating of oily wax, or de-oiling, has been employed for a long time for the beneficiation of slack wax, which usually contains 25-40% by weight of oil. Commercial scale wax usually contains 8-10% oil, while fully refined paraffin wax contains less than 4% oil, and high tensile strength wax has an oil content of less than 1.5%, as determined by ethylene dichloride.

In the sweating of wax, it is difficult to judge when the oil has been removed to the desired extent from the wax remaining in the sweating pans. This is due to the difficulty in obtaining a representative sample of all the wax, and to the prolonged time consumed in determning the oil content by the selective solvent method.

In its U. S. 2,406,210, Atlantic Refining Co. discloses a control method whereby it is claimed possible to produce wax of reduced oil content rapidly and without substantial loss of wax in the sweat oil. Use is made of the relationship of melting point and refractive index of the sweated wax and the sweat stream. In actual practice, a sample of an oily wax is experimentally sweated by slowly raising the temperature of the mixture, successive samples of the sweated material are withdrawn, and melting point, refractive index, and oil content determined. From these data it is possible to determine the point at which sweating should be discontinued to obtain a product of the desired oil content.

In Fig. 1, the refractive index is plotted against melting point, and lines AB and CD represent the limits within which lie the majority of the hydrocarbons present in substantially oil-free waxes. Pure straight chain paraffin hydrocarbons will be found to lie along line AB, while the substantially oil-free waxes may lie anywhere within the area defined by AB and CD. The equation for the line AB is

$$n = 1.3950 + 0.000242T$$

while that for line CD is

$$n = 1.3793 + 0.0004T$$

where n is the refractive index at 176° F. and T is the ASTM melting point in °F.

On the drawing in Fig. 1, is also plotted a curve defined by points E, F, G, H, I and J, representing the refractive index-melting point relationships of successive sweat stream samples from an experimentally sweated heavy paraffin slack wax having an initial oil content of 33.4% by weight and a melting point of 106° F. The experimental data for the sweat stream and sweated wax at each of these points are given in Table 1.

Referring again to the drawing, the constituents of a hydrocarbon wax, such as a substantially oil-free paraffin wax, have refractive index-melting point relationships which fall within the area defined by the lines AB and CD. Liquid constituents of paraffin distillate, however, exhibit relatively high refractive indices, and when the refractive index-melting point relationships of the first sweat stream sample is found to lie, for example, at point E, it is immediately known that considerable oil is present. When the slack wax is subjected to further sweating, however, the sweat stream shows progressively less oil and therefore the points will be found to move to the left as indicated at F, G, H, and I on the drawing. At such time as the quantity of oil in the sweat stream samples has reached a very low value, for example, point I, the successive points will no longer proceed to the left of the drawing but will rise, due to the increasing melting points, and inasmuch as such samples are approaching the composition of substantially pure wax (point J), the points will roughly parallel the line AB. When such condition is reached, the wax remaining in the sweating pans is substantially free of oil.

For any particular wax stock, it may be determined experimentally how close the refractive index-melting point value of the sweat stream must approach the

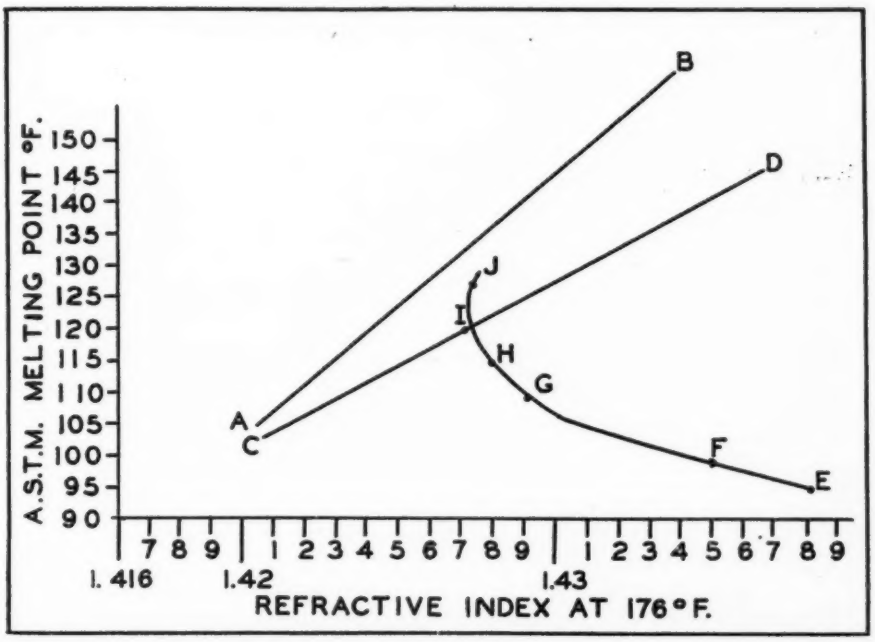


Fig. 1—Refractive index of wax at 176° F. vs. A. S. T. M. melting point, °F.

TABLE 1—Properties of Sweat Stream and Sweated Wax.

	Sweat Stream			Sweated Wax					
Point	R. I., 176° F.	M. P. ° F.	Percent Oil	M. P., ° F.	Percent Oil	Wt. % Yield	Hardness 86° F.	Hardness 95° F.	Tensile Strength
E	1.4382	95	37.5	...	...	...	...	...	...
F	1.4350	99	28.5	...	...	...	...	...	...
G	1.4291	109	14.9	...	...	...	...	...	...
H	1.4280	115	8.6	126.6	2.0	29.8	...	...	...
I	1.4273	120	4.1	129.0	1.0	23.2	30	0	132
J	1.4275	127.5	1.1	133.5	0.3	6.3	90	30	378

line AB before the sweated wax remaining in the pans is of desired quality. Each wax stock has a particular curve of its own, and the position of the curve on the accompanying drawing may change as either the boiling range or the source of the wax distillate, and therefore the wax stock, varies.

In order to produce from a slack wax stock having an oil content of from 25% to 40% by weight, a commercial grade of scale wax having an oil content of 8% to 10%, it has been found that the refractive index-melting point relationship of the sweat stream should fall within the limits defined by lines having the equations

$$n = 1.3998 + .000242T$$

and

$$n = 1.4003 + .00242T$$

For the production of a fully refined paraffin wax of commercial grade having an oil content of less than 4% by weight, for example, 1.5% to 4%, the refractive index-melting point relationship of the sweat stream should fall within the limits defined by lines having the equations

$$n = 1.3978 + .00242T$$

and

$$n = 1.3983 + .000242T$$

And for the production of high tensile strength wax containing less than about 1.5% of oil, and preferably less than 1% of oil, the refractive index-melting point relationship of the sweat stream should fall within the limits defined by lines having the equations

$$n = 1.3964 + .00242T$$

and

$$n = 1.3969 + .00242T$$

In another aspect of the present invention, it has been found that the refractive index of the sweat stream is, per se, a valuable guide in indicating the point at which sweating should be terminated, particularly in the production of waxes of exceedingly low oil content, i.e., less than about 1% by weight of oil. By determining the minimum refractive index of the sweat stream and then terminating sweating when such value is reached, the resulting sweated wax will contain little or no oil. Referring to the drawing, it will be seen that the minimum refractive index of the sweat stream is reached at a point between I and J, and that the oil content of the sweated wax when the sweating was stopped at I was about 1%. By terminating the sweating at the minimum refractive index between I and J, a somewhat higher yield of low oil content wax should be obtained than by continuing the sweating to the point J.

Reducing Evaporation Losses

A method of reducing evaporation losses has been recently described in a patent (U. S. 2,406,540) issued to Standard Oil Development Co. This method, applied to closed storage equipment containing relatively volatile liquids, is outlined in Figure 2. It comprises in first heating the closed vapor space just above the maximum temperature to which the storage equipment is to be exposed. This is accomplished by introducing live steam through valve 30. Thereafter, the system is exposed to temperatures of the atmosphere.

Steam is passed into the vapor space in amounts so controlled by the vapor temperature (via controller 10) as to maintain relatively uniform temperature conditions in the vapor space and to prevent an excessive pressure drop in the vapor space due to decreasing atmospheric temperatures.

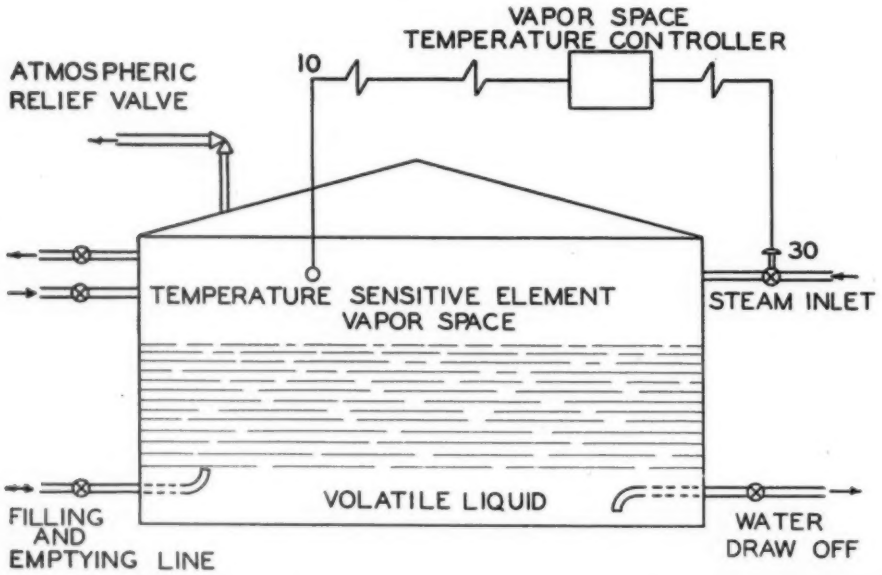
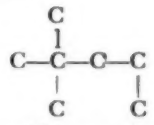


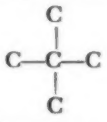
Fig. 2—Diagram of volatile liquid storage tank incorporating evaporation controls

Neopentane

Isobutylene polymers generally have the neo grouping as might be illustrated in the structure:



Hence, one might say that, by proper selective cracking, it should be possible to produce good yields of neopentane:



This hydrocarbon is a very valuable blending agent for aviation fuels.

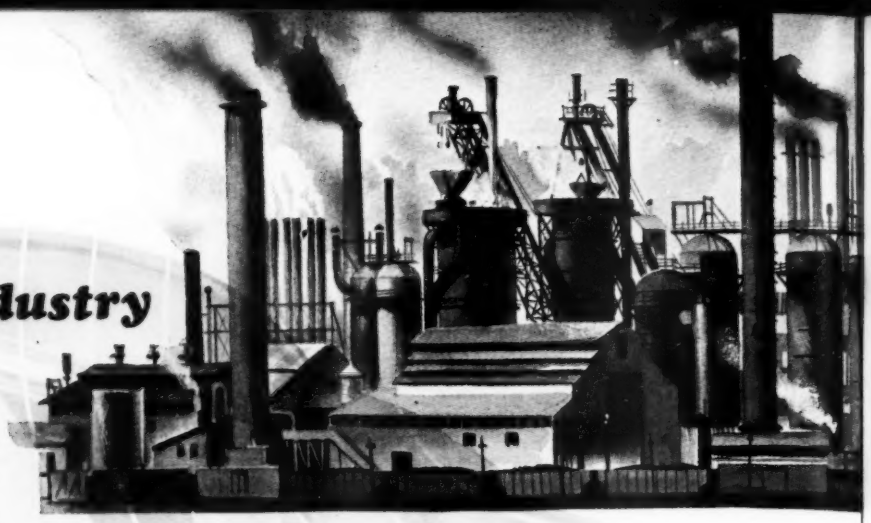
Such a procedure has been described by Bergsteinsson of Shell Development Co. in U. S. 2,394,743. One example discloses the hydrogenation of a 176°-199° C. fraction of isobutylene polymer to a bromine number of 5.6, fractionation to give a cut boiling between 170°-181° C. with bromine number of 0.5, followed by selective cracking in vapor phase over chromium oxide (11% Cr) on alumina at 500° C. and atmospheric pressure. The debutanized liquid product consisted almost exclusively of neopentane (m. pt. −19° C.).

Selected Patents of the Month

U. S. 2,406,375 (Foster Wheeler)—Fractionating column.
U. S. 2,406,394 (Howdy)—Aviation gasoline.
U. S. 2,406,423 (Victor Chemical)—Organic P-N compounds.
U. S. 2,406,421 (Wollner et al)—High vacuum fractionating still.
U. S. 2,406,477 (M. W. Kellogg) — $AlCl_3$ catalyst.
U. S. 2,406,544 (Texaco)—Paraffinic fuel containing carbonyl for super rich conditions.
U. S. 2,406,549 (Standard Oil Development)—Lubricant containing pour depressor.
U. S. 2,406,555 (Standard Oil Development)—Catalytic cracking.
U. S. 2,406,560 (U. S. A.)—Rocket motor.
U. S. 2,406,564 (Standard Oil Development)—Compounded lube oil.
U. S. 2,406,613-4 (Universal Oil Prods.)—Zirconia cracking catalysts.
U. S. 2,406,630-2 (Universal Oil Prods.) — Cyclo-olefins.
U. S. 2,406,633-4 (Universal Oil Prods.)—Isomerization.

listen!

WHAT'S THAT HUM YOU HEAR?



it's the crescendo of industry

heightening the demand for more lube oil!

As American industry shifts into higher gear, as automobile production and air travel reach new highs, and as more and more machinery hums in a rebuilt Europe—the demand for premium lube oils is mounting rapidly.

• Those refiners who plan now for early construction of lube oil facilities obviously will be in an advantageous position to profit briskly, as the lube oil demand increases.

• Lummus service includes every stage of process development, plant design, construction and initial operation. With complete facilities for pilot plant and semi-commercial operation, Lummus is equipped to study individual refinery conditions with a view to the design and construction of a plant that will give maximum yields of high-grade lube oils at minimum cost.

Lummus has designed and built a large percentage of the world's solvent refining and dewaxing capacity:

14 solvent refining plants now in operation
—3 more under construction;

19 solvent dewaxing plants
—3 more under construction.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

long life, low cost lube oil plants

LUMMUS

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
HOUSTON—Mellie Esperson Bldg., Houston 2, Texas
LONDON—78 Mount Street, London, W. 1, England

Write for a copy of "Development of the Postwar Petroleum Refining Picture."

CRUDE OIL ASSAYS

Prove Valuable Working Tool for Refiner's Design Engineers and Plant Operators

By J. L. PETERSEN, Technical Service Division, and H. G. CANNON, Refinery Operating Control, Standard Oil Co. (Ohio)

"Workups" of samples of crude oil in the laboratory, supplemented with calculated data on refining costs, are put to practical use by the design engineers and plant operators of one large refiner, as well as serving for accounting and other conventional purposes. These assays are used in engineering calculations where new processes or new products are under consideration. They also serve as the basis for the theoretical yields for individual plant operations, against which operators compare actual yields. The assays also are the basis for the selection and assignment of crudes to individual refineries.

In making up the assays, product yields are determined both by conventional "workups" of samples and by correlations with plant experience and other data. Refining costs are taken as marginal costs for individual plants, based on operations to produce maximum volumes of motor fuel of the desired quality. The assay carries a penalty for high sulfur content, if desalting is required and if saleable kerosines cannot be produced from the crude oil sample.

AS RECENTLY as the early 1930's, the Standard Oil Co. (Ohio) was interested in little more than the gravity of the crude oil its refineries processed and the B. S. & W. content. Gravity was of interest because higher gravity crudes contained more straight-run gasoline and were of more value. The octane level of motor gasoline at that time was only 60 A.S.T.M. Gravity also served as a check on the quality of crude, since the crude came mostly from the Mid-Continent field, and was of relatively uniform composition.

Low B. S. & W. was essential to avoid refining difficulties. In addition, the refiner wanted the volume of oil for which he was billed to represent actual oil, and not sand and water, so an exact B. S. & W. content was needed to correct the volume.

By 1935, the refinery laboratories were obtaining quarterly workups containing considerable information on the crude oil. In addition to gravity and B. S. & W., tests were run for pour point, sulfur content, viscosity on the crude. A 400-E. P. gasoline was cut for yield and octane number. In addition, the viscosity-gravity-constant (V.G.K.) was determined on the crude, and an aniline point-gravity curve made on overhead distillation cuts. This represented a definite attempt to classify the type of oil, whether paraffinic, naphthenic, or something else.

By 1938, the quarterly workups were expanded to split the 400-E. P. naphtha fraction into light and heavy naphtha of varying lengths; ie. 25% light and 75% heavy; 50% light and 50% heavy; 75% light and 25% heavy; and of course, total 400-E.P. naphtha. In addition to octanes on these cuts, the amount of TEL was determined to take each of the light naphthas to 70-octane.

In 1939, the quarterly workup procedure had been standardized, using the same method now employed by the refineries to work up 5-gal. crude oil samples. In addition to the tests previously obtained, the crude oil was now checked for salt content and for "corrosive" sulfur liberated as H_2S or mercaptan on distillation to 750° F. The naphtha workup was shortened to two cuts, a 300-E.P. and a 400-E.P. gasoline, on each of which octane and lead susceptibility were obtained. Vapor pressure determinations were also made on the gasolines.

A kerosine cut was made and tested for distillation, mercaptan sulfur, total sulfur, color, and viscosity. A constant known as the ring number was calculated from the gravity and viscosity, to indicate the type of hydrocarbons present, and thereby the burning quality of the kerosine. The residues from distillation for gasoline and for kerosine were tested for gravity and viscosity.

In addition to the regular quarterly workups, many special samples of crude oil have been analyzed by this procedure. It has been used as the basis for the economic evaluation of crude oils, which will be discussed in detail later in this article.

Also in 1939, a crude assay procedure was set up for analysis of large samples to produce sufficient of the various cuts and blends to allow more detailed workup of the products than possible on the 5-gal. workups. A 50-gal. T.B.P. still and an asphalt flash still were erected in the Technical Service laboratory for this purpose. The large size was chosen particularly to provide sufficient stock to allow an evaluation of the asphalt.

Since 1939, the only real addition to the analytical procedure for evaluating crude oils has been the HCL evolution test to supplement salt determinations.

"Standard" Crude Selected

The current method of evaluating crude oils on a dollar and cents basis was developed around 1940. A standard crude was chosen as a basis for comparison with other crudes. Since Salem, Ill., crude then was available in large volume and was of uniform composition, and since more was known about this crude than others processed at that time, it was made the standard basic crude, and evaluated at each of the four gasoline refineries. The refineries were considered to be operating for maximum gasoline, making as products gasoline of 81.5 Research octane, asphalt or coke depending on location, fuel oil and fuel gas. All straight-run distillates between light naphtha and asphalt were cracked, as well as coke still gas oil where coking was used.

The yield and properties of direct distillation products were obtained from the laboratory assay of a 5-gal. sample of the standard Salem crude, using the standard procedure for quarterly workups. The yield of light naphtha was taken as that currently cut in each refinery. The octane was taken from the assay data for the chosen light naphtha yield The remainder of the 400-E.P. naphtha was considered as heavy naphtha for re-

forming. The yield of gasoline, gas and tar from the heavy naphtha at each refinery was taken from the average data for reforming at each of the refineries at that time. The octane of the reformed gasoline was obtained from a correlation relating yield with feed octane. Fig. 1 illustrates the correlation which was developed for Michigan naphtha.

The asphalt flux yield was determined from a correlation with the V.G.K. of the still bottoms from the kerosine run. The basic data for this correlation were obtained from two of the large scale crude assays in the Technical Service stills. It was found that the viscosity gravity constant of various length reduced crudes from the same crude oil was not a constant, but increased as the reduced crude became heavier. However, the asphalt in any reduced crude was found to have a linear relationship to the viscosity gravity constant. Thus, a 50% reduced crude with a V.G.K. of .850 would contain 21% asphalt. This represents 10.5% asphalt on crude. The material between heavy naphtha and asphalt flux was all considered as gas oil for cracking.

The yield of gasoline from gas oil cracking was obtained from a correlation with aniline point and gravity of the gas oil. Since this represented operation at 12 API tar gravity, the yield was corrected to the actual tar gravity common at each refinery in 1940. The tar gravities used were 10, 7, 3, and 6 at the respective refineries.

The gas yield was obtained from still another correlation, relating yield of 100% C_4 distillate with gas yield.

The octane of the gasoline from gas oil cracking was obtained from a correlation with the "K" factor of U.O.P., based on the principle that the degree of paraffinicity of the feed stock affects the octane of the cracked distillate. A mass of data on gas oil cracking at the same pressure and time level as used in the company's own operations was plotted, see Fig. 2, and a curve drawn relating "K" factor with octane. Experience indicated that the company's thermal cracking equipment averaged higher octanes than the mass of data used, so parallel curves were drawn to represent practice at each of the refineries.

The coke yield for non-asphaltic operation at two plants running to coke was based on plant experience in 1940, using the same yield of reduced crude for coke still feed, and the same coke, gas oil and gas yield from reduced crude as found at each of the two refineries. All material between heavy naphtha and reduced crude feed to the coke stills was considered as virgin gas oil for cracking, and was handled by the same procedures as used for virgin gas oil from asphaltic operations.

The coke still gas oil was considered as cracking feed stock, and yields and octanes determined by the same procedure as for virgin gas oils. The gravity of the coke still gas oil was taken as 32 API, corresponding to plant observations. The aniline point and "K" factor needed to determine yields and octanes were determined from the laboratory distillation data on the crude, assuming the coke still gas oil corresponded to a virgin gas oil of the same gravity.

The yields of 100% C_4 gasoline and of gas from the desired combination of operations at each refinery were then adjusted for incomplete plant recovery of butanes in making the desired 10-lb. RVP gasoline. A further adjustment was made for polymer gasoline produced at the catalytic "poly" plants.

Used Arbitrary "Poly" Gasoline Yield

Based on plant experience, an arbitrary yield of "poly" gasoline of 2% on crude was used, with a corresponding reduction in gas yield of 2% on crude. This was later revised to 20% of the total gas produced, which came very close to 2% on crude for Salem crude. Since the gas yield at two refineries exceeded that which could be burned as refinery fuel, the usable gas yield at these two refineries was adjusted to a maximum of 8% on crude for economic considerations.

After yields of all final products and octanes of the gasolines were obtained for the desired operations at each refinery, the value of the products was determined, using for the standard basic crude evaluation the net backs set up by the company for guidance of the sales department. The gas values adopted represented their coal replacement value at each of the refineries.

The amount of lead required to make 81.5 Research octane gasoline was determined independently for each gasoline used in making up the final gasoline blend at each refinery. The light naphtha lead requirement was obtained from the crude assay data on lead susceptibility. The lead requirements for the cracked gasolines and the reformates were obtained from lead susceptibility charts for the Salem crude being considered, based on plant data on that crude From the lead requirements to take each of the gasolines to 81.5-octane, the average lead requirement for the entire gasoline blend was calculated. The cost of the lead was then calculated at a rate of 0.20c per cc.

The manufacturing costs of the crude were estimated on a marginal basis, assuming the refinery was already running crude oil with its existing equipment and personnel, and that the cost of running a barrel more of the standard crude, or of replacing a barrel of one type with a barrel of another type crude, would not change the manpower or equipment or overhead costs, but would affect principally the utility and maintenance costs. The marginal costs of refining for each operation at each refinery were determined from cost accounting department data on 1939 costs, and allocated to the operations of crude distilling, naphtha cracking, gas oil cracking, coking, gasoline treating, and polymerization in proportion to the feed rate to each operation due to running one barrel of marginal crude.

The marginal refining cost and the TEL cost to produce 81.5 Research octane gasoline were subtracted from the total refinery value of the products to give the refinery value of the crude, before penalties.

The crude was penalized in value for three possible causes. If the corrosive sulfur by distillation was higher than 20 lbs/1000 bbl., a corrosion penalty was charged to offset the additional maintenance costs which would result from processing such a crude. The amount of penalty was determined from a graph

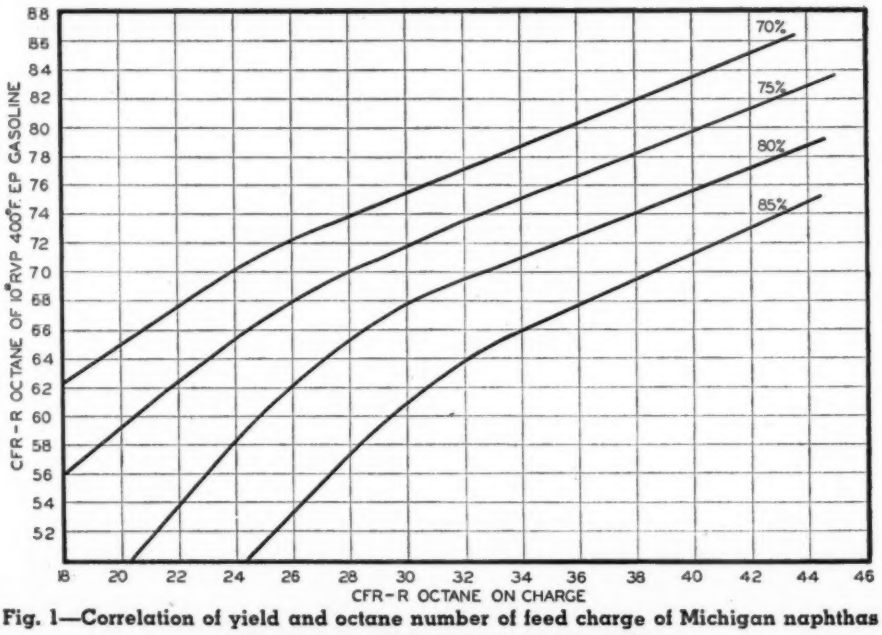


Fig. 1—Correlation of yield and octane number of feed charge of Michigan naphthas giving octane number of reformed gasoline

SANTOPOUR B

for quick winter turnover in motors and sales

When you blend your winter oils with Monsanto Santopour B,* you add all the advantages repeatedly demonstrated by this pour-point depressant in the field of lubricant additives. It assures quick starts at low temperatures and quick starts in sales.

Santopour B is an improved Monsanto product that contributes these advantages to your blended oils—

1. Optimum effectiveness in base oils of all types.
2. Dollars-and-cents economies.
3. Improved pour-point stability.
4. Improved pourability in winter storage.

Test data indicating optimum potency in typical base oils and other characteristics of Santopour B are available. Contact the nearest Monsanto District Office, or write: MONSANTO CHEMICAL COMPANY, Petroleum Chemicals Division, 1700 South Second Street, St. Louis 4, Missouri... District Offices: New York, Chicago, Boston, Detroit, Cincinnati, Charlotte, Birmingham, Los Angeles, San Francisco, Seattle, Montreal, Toronto.

MONSANTO CHEMICALS
SERVING INDUSTRY...WHICH SERVES MANKIND

*Reg. U. S. Pat. Off.

of corrosive sulfur versus penalty ranging from zero at 20 lbs to 10c/bbl. at 400 lbs. Sweet Salem crude contained 18.8 lbs/1000 bbl. of corrosive sulfur.

A penalty was charged if salable kerosine could not be produced from the crude, since standard Salem crude contained good kerosine. The value of the kerosine was set at 3c/bbl. of crude since the difference in netback between kerosine and furnace oil at the normal kerosine yield represented about 2c/bbl. of crude, and an additional cost of about 1c/bbl. of crude would result from costs of buying outside kerosine and redistributing same to customers in order to meet contracts.

To be acceptable the kerosine cut from the laboratory crude assay must have a mercaptan sulfur content under 0.05%, total sulfur content under 0.125%, and a ring number of 40 or over to indicate good burning quality. The ring number is an empirical value determined from gravity and thermo-viscosity at 60° F. High ring numbers indicate paraffinic stocks.

A desalting penalty was charged if the crude contained so much salt that desalting would be required. In general, a salt content of 150-200 lb./1000 bbl. was considered excessive, and a fixed penalty of 2c/bbl. invoked. The standard Salem crude had 130 pounds of salt so no penalty was applied except at one plant, where the combination unit required a desalted feed.

After all the penalties and costs were subtracted from the product values, the net refining value of the crude was obtained. On the standard crude the net value ranged from $2.347/bbl. to $2.489/bbl. The standard value of the crude was then expressed in a decimal form for later use in comparing other crudes. At one plant, for example, the standard was I 2.76.21.04 AA2 Non-Asphaltic; nearing Illinois crude, $2.76/bbl. product values, $0.21 marginal refining cost, $0.04 lead cost, corrosion penalty absent, kerosine penalty absent, desalting penalty 2c/bbl., operation non-asphaltic. Table 1 represents an evaluation of crude for the refinery referred to above.

TABLE 1—Evaluation of Salem, Ill., Crude for one Refinery

for one Refinery	
Quality of Crude	
Gravity of crude, °API	38
Corrosive sulfur, lbs/1000 bbls.	18.8
Total sulfur, per cent	0.22
Salt, lbs./1000 bbls.	130
400 E.P. naphtha, per cent	33
CFR-R octane of 400 E.P. Naphtha	54
Str. run cut, per cent	14
Octane str. run cut	68.3
Gas oil gravity (cr. stk.)	33.5
Gas oil UOP "K" factor	11.90
Asphalt per cent on crude	.....
Asphalt quality factor	.....
Total Gaso. yield (81.5 CFR-R octane)	70.5
Product Values ($ bbl.)	2.756
Refinery cost ($ bbl.)	
Marginal mfg. cost	0.210
Lead cost	0.037
Corrosion penalty	0.000
Kerosine penalty	0.000
Desalting penalty	0.020
Total costs and penalties	0.267
Net Refining Value ($/bbl.)	2.489
Standard value of Crude	I 2.76.21.04 AA2 Non-Asphaltic

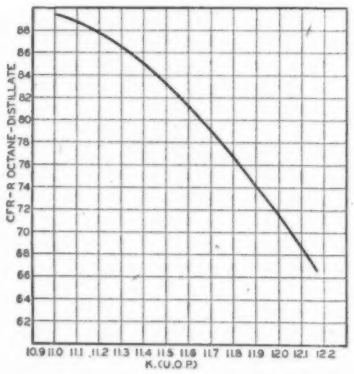


Fig. 2—Effect of feed characteristic on octanes from gas oil cracking

Evaluation of Other Crudes

Other crude oils are generally evaluated on the same basis as the standard Salem crude, for comparison with the standard. The same standard workup procedure is employed, or a lab procedure which will give equivalent data on the properties of the crude. The identical procedure is followed for yields and product values as was done on the standard at the refinery for which the comparison is to be made. The butane recovery for Michigan crude at one refinery varies from the standard due to the large amount of reforming. A factor of 94% gasoline on theoretical is used instead of the standard 99%.

The same unit product values, lead cost, and marginal refining costs are used as in the standard assay. In this manner a comparison is made between the unknown and the standard crude under identical conditions. If any penalties apply, these are deducted to determine the net refining value. The results of the comparison are expressed in terms of differences from the standard, using plus or minus signs to denote whether the value listed is greater or less than the standard. Any special properties are covered by means of a note attached to the tabulated evaluation.

Sometimes it is desirable to evaluate, or rather to compare, two different crudes at a given refinery under current conditions, or to determine whether a crude is worth more at one refinery than at another at current conditions. The same basic method of evaluation is used, except the marginal refining costs will be the current costs at the refinery under consideration, the lead cost will be the current lead cost, and the product netbacks will be the current product netbacks. Similarly, comparisons can be made using any set of product netbacks desired, to determine for example the effect of a decrease of 1c/gal. in the value of gasoline.

For use in comparing crudes an improvement was developed over the method used in the standard evaluation for determining light naphtha yield and octane. Light naphtha was considered as 65 octane clear, with an allowance made for each refinery for differences in plant and laboratory fractionation. At one plant 7 octanes were allowed; that is the yield of 72-octane naphtha from the assay was taken as the yield of 65-octane naphtha which could be cut in the plant. Allowances at the other three refineries were 0, 4 and 3 octanes.

Assays for Design Engineer

The comparative evaluation of a crude oil in terms of its dollar and cents value is not the only purpose of a crude assay. One of the other major purposes of this work, particularly of the large scale assay made in the Technical Service stills, is to furnish basic data on yields and properties of various fractions of the crude for engineering calculation and design.

The engineer will find a great deal of valuable data in a crude assay, starting off with accurate distillation data on the crude to be processed. To make this information more useful, the T.B.P. distillation curve is usually presented as a graph. On the new assay reports, a second curve has been added to the T.B.P. curve to show the gravity of the total overhead product at any given per cent vaporized. This will be of considerable value in calculations involving the heat content of the crude oil.

The properties of various boiling range virgin stocks are frequently of value to the engineer. One of the properties which should be of more value than in the past is viscosity. The viscosity of a stock can be obtained by several different methods, and expressed in various units. To cover the range of viscosities encountered in a crude assay, several methods are used. For light stocks such as gasoline and kerosine, the thermo-viscosity is frequently used and often appears in specifications for these materials. For overhead distillate stocks of a heavier nature, from furnace oils through heavy lubricating fractions such as cylinder stock, the Saybolt Universal or Furol viscosity, depending on the viscosity range, is usually used.

The Kinematic procedure has been developed for use on clean stocks from gasoline through cylinder stock, and has many advantages over the thermo and Saybolt methods. The kinematic viscosity in centistokes can be readily obtained using only small samples, can be determined rapidly, and can be quickly checked with the same sample if desired. The results can be easily transposed to units encountered in engineering calculations. A continuous viscosity scale is available by one method to cover the entire field of viscosity determinations.

On heavy residual stocks, particularly

3 PRESSURE STILLS

. . . a high pressure still, an intermediate still and a low pressure still fabricated by us for a cycling plant in the west.

● The three pressure stills shown in the center of the above view are part of a high pressure absorption unit at a cycling plant. The high pressure still, which appears in the foreground, is 49 ft. high by 11 ft. in diam. and has twelve trays. Its operating pressure is 185-200 lbs. per sq. in. The intermediate still, which operates at 50-60 lbs. per sq. in. and is 12 ft. in diam. by 66 ft. high, has eighteen trays. The low pressure still is 61 ft. high by 8 ft. in diam. and has twenty-four trays. Its working pressure is atmospheric to 5 lbs. per sq. in. In addition to the stills, we also fabricated the absorber tower and depropanizer tower that appear immediately to the right of the stills.

Our three plants have fabricated refinery equipment for many years. When planning installations of this type, write our nearest office for complete information or quotations.

CHICAGO BRIDGE & IRON COMPANY

Birmingham 1	1534 North Fiftieth Street
Houston 1	5618 Clinton Drive
Tulsa 3	1607 Hunt Building
New York 6	3345-165 Broadway Building
Cleveland 15	2206 Guildhall Building
Atlanta 3	2150 Healey Building
Chicago 4	2125 McCormick Building
San Francisco 11	1260-22 Battery St. Building
Philadelphia 3	1614-1700 Walnut St. Building
Los Angeles 14	1422 Wm. Fox Building
Washington 4	703 Atlantic Building
Detroit 26	1513 Lafayette Building

Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PENNSYLVANIA

when viscosities are measured at temperatures above 210° F., the Saybolt viscosimeter is usually preferred to the kinematic viscosimeter.

To make the crude assay reports more useful, a new graph paper for viscosity temperature relationships has been developed. It has as the basic scale the kinematic viscosity in centistokes, which is more readily obtained in the laboratory and more frequently used by the engineer. Auxiliary scales are drawn in the margin to show the Saybolt Universal, Saybolt Furol, and thermo-viscosity units for rapid conversion from one unit to another.

Since there is an effect of temperature on the conversion from Saybolt units to centistokes, this conversion cannot be made by simply following the horizontal line representing the corresponding centistoke reading at the side of the graph. Instead, it is necessary to connect the two Saybolt scales on either side of the graph by a straight line through the Saybolt reading to be converted.

The intersection of the straight line with the temperature line corresponding to the temperature at which the Saybolt viscosity was obtained, gives the corresponding centistokes at that temperature. To make this procedure simpler the advisability of adding Saybolt scales adjacent to the common viscosity temperatures 100° and 210° F. is being considered.

The viscosity-temperature lines for the cuts and blends from a given crude fall into a family of parallel curves. This is demonstrated by the data on a sample of Illinois crude oil, where viscosities were determined on cuts and blends ranging from a gasoline fraction boiling between 300 and 350° F., up to a 115-penetration asphalt flux obtained by vacuum reduction, in fact even to a 66-pen blown asphalt prepared from a 182-pen flux.

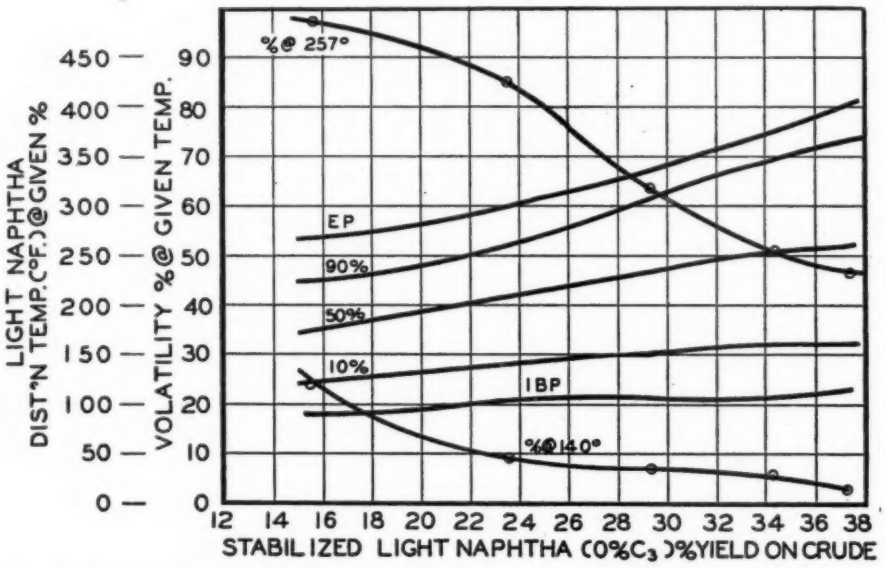


Fig. 3—Distillation characteristics of naphthas plotted against light naphtha yield. (One of 4 charts for presenting assay data for use in determining optimum level of reforming)

Development of a suitable graph to show the relationship between viscosity and boiling point of a narrow cut, and between its viscosity and mid per cent point in crude, will further increase the utility of the viscosity data. Preliminary attempts to set up such a graph indicate that if either viscosity paper is used, or if a logarithmic scale is used for viscosity and a linear scale for temperature or mid per cent point, a smooth curve will result, although not quite a straight line. More complete data in the cylinder stock range are needed to finish this work.

Assays and Plant Operations

The detailed workups of the various blends furnish considerable data of interest to the plant operators as well as to the engineer. The theoretical yield of various stocks can be compared with the yields actually obtained. An example of this is the yield-octane penalty applied in the economic evaluation of crudes to account for poor plant fractionation between light and heavy naphtha. When the crude stills at one refinery were revamped in 1943, the fractionation between light and heavy naphtha improved sufficiently so that the penalty on light naphtha octanes was cut from the 7 octanes used in the early comparisons to 3 octanes for comparison on a current basis.

The yield and quality of asphalt obtained by the crude assay have been found to correspond closely to those obtained in the plant. A notable example of the close correlation was found when assaying Mississippi crude. When the normal 250-pen asphalt flux was oxidized, the resulting asphalt was found deficient in ductility. A heavier flux was then oxidized, and found satisfactory. On the basis of the laboratory work, it was recommended that blown asphalts be prepared from 150-200 pen flux. The refinery experience when Mississippi crudes were processed bore out this observation.

Many correlations have been developed to show the type of stock present in various fractions of crude oil, to account for differences in plant behavior of corresponding cuts from various crudes. The differences in quality have been expressed in terms of correlation indices, usually reflecting the types of hydrocarbon which predominate. The viscosity index of lube oil fractions, the ring number of kerosine fractions, the viscosity-gravity constant (VGK) of residual oils, the "K" factor of UOP for a wide range

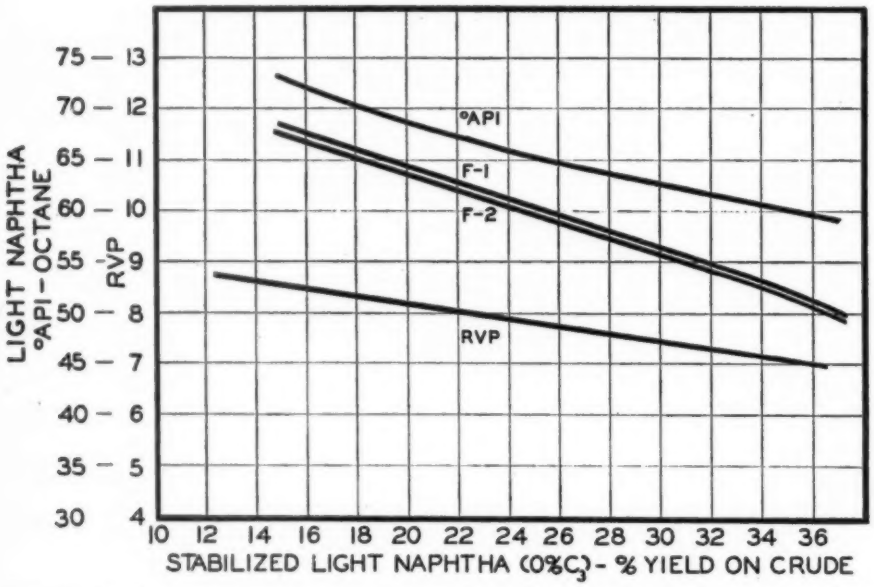


Fig. 4—Gravity, vapor pressure and octanes plotted against light naphtha yield. (One of 4 charts for presenting assay data for use in determining optimum level of reforming)

of petroleum fractions, are examples of these indices.

An index to measure asphalt quality has been developed, based on the gravity and viscosity of the reduced crude to be processed for asphalt. This quality factor is a reduced crude viscosity gravity constant.

Some of the information developed in the crude assay has been of sufficient value to the plant man to warrant frequent observations to follow changes and trends. One item of particular interest has been the corrosive nature of the crude. As a result, the tests for salt, for HCl evolution, for sulfur, and for corrosive sulfur by distillation are run every two weeks, and a continuous graphical summary made for each refinery.

Determining Depth of Reforming

The method of presentation of the data on naphthas has been changed in the current report form to increase its utility in determining the optimum level of reforming. Light naphtha blends are prepared covering a range from 250 EP. to 400 EP. The distillation characteristics of these naphthas are plotted against the light naphtha yield as shown in Fig. 3. The volatility at 140° and 257° F. are included. On a separate graph using the same abscissa, the gravity, vapor pressure, and octanes of the naphthas are plotted. See Fig. 4. Thus, for any light naphtha end point, gravity, octane, or yield, the entire properties of the light naphtha can be determined.

On Fig. 5 the yield of heavy naphtha is plotted against the yield of light naphtha, the same abscissa as shown on the other curves. The gravity and octane of the heavy naphtha is also shown. To complete the properties of the heavy naphtha a fourth graph, Fig. 6, is made to show the distillation characteristics

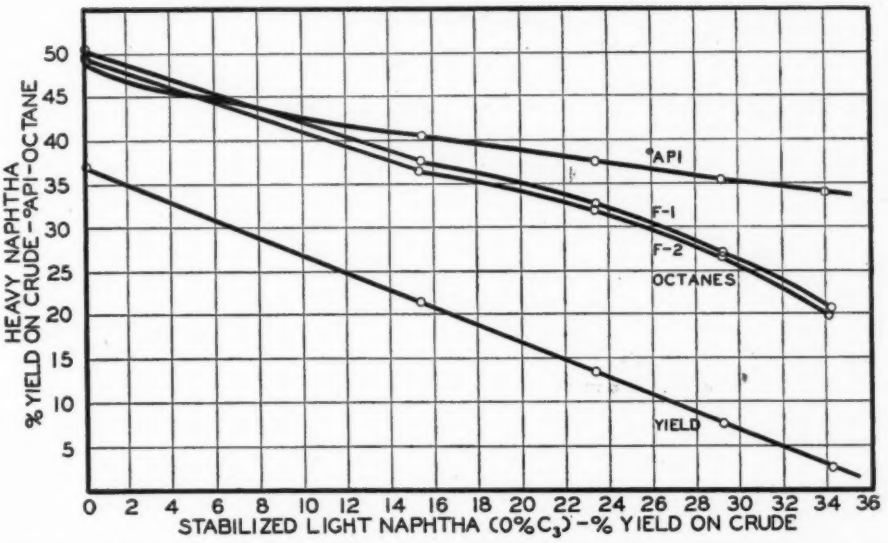


Fig. 5—Yield, gravity and octane of heavy naphtha plotted against light naphtha yield. (One of 4 charts for presenting assay data for use in determining optimum level of reforming)

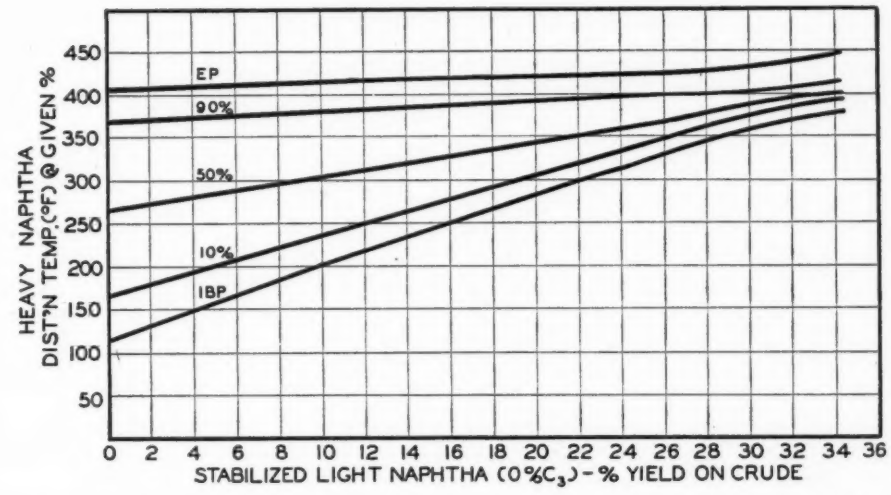


Fig. 6—Distillation characteristics of heavy naphtha plotted against light naphtha yield. (One of 4 charts for presenting assay data for use in determining optimum level of reforming)

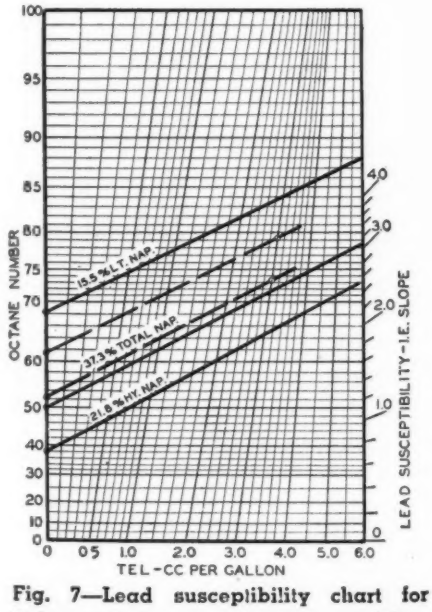


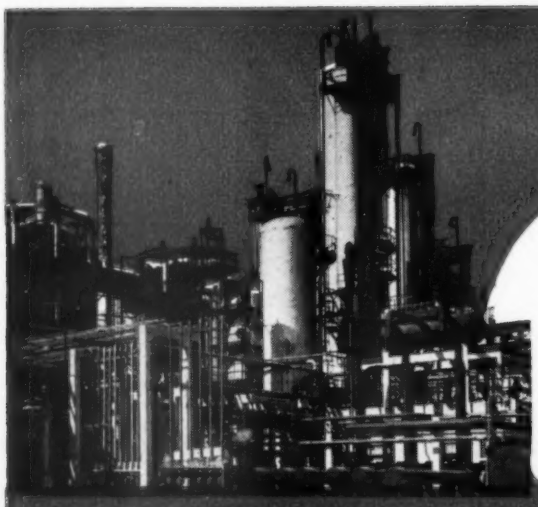
Fig. 7—Lead susceptibility chart for light and heavy reformed naphthas plotted on an Ethyl Blending Form

of the heavy naphtha. Since all four of these graphs have been drawn with the same abscissa, the yield of light naphtha, they can easily be arranged on a single graph sheet so that properties of the light naphtha and the corresponding heavy naphtha can be determined readily for any light naphtha yield, or for any other property of the naphtha such as end point or octane.

To complete the picture a fifth graph is prepared for presentation on the same sheet. It is the lead susceptibility data shown in Fig. 7. The data plotted on these five graphs were taken from an old Illinois crude workup, on which different fractions were used for susceptibility data then currently used, so the solid lines on Fig. 7 represent the estimated lead susceptibility curves for a 250-EP. light naphtha, for a 400-EP. total naphtha, and for the heavy naphtha which corresponds to the 250 E. P. light naphtha. The broken lines represent data on the actual cuts made in the workup.

Future Developments

Many additional uses have been found for crude assays than those presented in this paper, and many more will be found in the future. Already suggested are detailed lube oil studies to tie in with yields of solvent treated oils, with pressability, with quality of wax. A revision of evaluation methods may be made to take into account plant limitations in capacity for certain operations such as reforming, and to take into account operations to produce other final products than gasoline, fuel oil, fuel gas, and asphalt or coke. A correlation between gas oil quality, as indicated by some index such as the UOP "K" value, and yields on cracking in the company's equipment, both thermal and catalytic, may be a logical development.



PETROLEUM

All primary products from crude • Pure hydrocarbons by fractionation or extraction • Catalytically cracked gasoline • Aviation gasoline and all components • Thermally cracked and reformed motor gasolines • Home burning oils • Propane deasphalted stocks • Solvent-extracted lubricating oils • Solvent-dewaxed lubricating oils • Filtrol fractionated lubricating oils • Asphalts • Visbroken fuels • Coke.

EXPERIENCE

The petroleum, petro-chemical and chemical industries have become so interrelated that cumulative experience in all three carries definite advantage in process engineering and in designing and constructing new plants in any one of them.

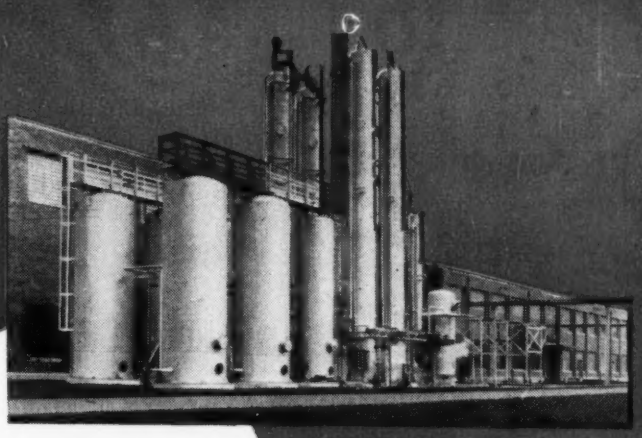
Badger is unique in the length, breadth and amount of such experience. It is evident from the accompanying partial list of products for which this organization, in its long career, has provided successful production facilities, that Badger has the versatility to execute the design, procurement and erection of any size petroleum-refining, petro-chemical or chemical plant—anywhere in the world.

E. B. Badger & SONS CO. • Est. 1841

BOSTON 14 • NEW YORK • SAN FRANCISCO • LONDON

PROCESS ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM, PETRO-CHEMICAL AND CHEMICAL INDUSTRIES

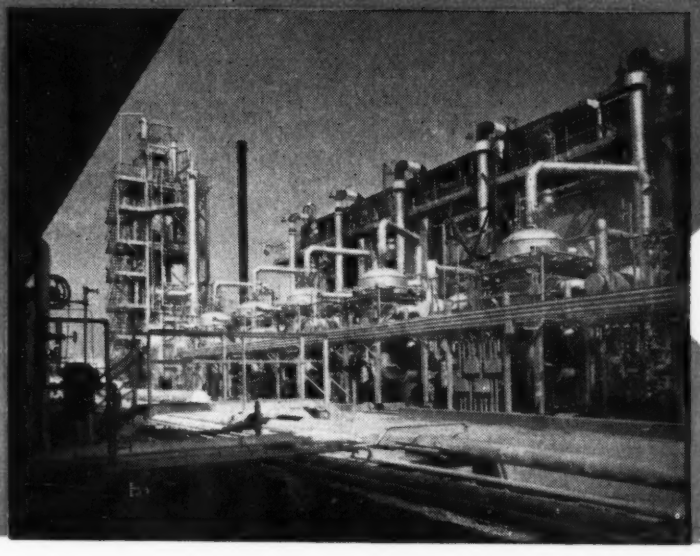
LICENSING AGENTS FOR THE TCC PROCESS AND THE HOUDRY CATALYTIC CRACKING PROCESSES



CHEMICAL

Industrial ethanol, isopropanol and higher alcohols • Methanol, synthetic and from wood distillation • Ethyl acetate, butyl acetate, dibutyl phthalate and other esters • Synthetic acetic acid and acetic anhydride • Nitrobenzene and other nitro-aromatics • Carbon tetrachloride, chloroform and other chlorinated hydrocarbons • Phenol, cresols, etc., from tar acids • Synthetic phenol • Aniline and other amino-aromatics • Beverage alcohol and spirits • Ethyl ether and isopropyl ether • Acetone and other ketones • Glycerine and glycols • Maleic and phthalic anhydride • Styrene • Ammonia • Fats and fatty acids • Ethyl benzene • Formaldehyde • Nitroparaffines • Synthetic camphor • Explosives and smokeless powder • Penicillin and streptomycin.

with all three



Butadiene • Styrene • Benzene • Toluene • Trinitrotoluene • Ethyl, isopropyl and other alcohols • Acetic anhydride • Formaldehyde • Maleic and phthalic anhydride • Nitroparaffines and their derivatives • Chlorinated hydrocarbons • Pure hydrocarbons.

PETRO-CHEMICAL

Oil Heating Furnace Produces Steam for Processing Also

Patents are issued every week by the U. S. Patent Office on new or improved devices designed to increase profits, produce better quality products, improve the handling and transportation of equipment and materials, effect better and safer working conditions, and for many other reasons.

Many of these patented devices are of particular interest to the petroleum processing industry. Although they may not yet be available to the public, Petroleum Processing believes a survey of the more important inventions will be of value, and will present a monthly digest. Descriptions and drawings are from the patent itself. The inventor's name and company, if any, will be given with each item.

- **New oil Heater produces process steam also**
- **Constant current for cathodic pipeline protection**
- **Self-cleaning laminated zinc electrode prevents corrosion**
- **Aids accurate metering of volatile liquids**
- **Rotates pipe in either direction without removal**

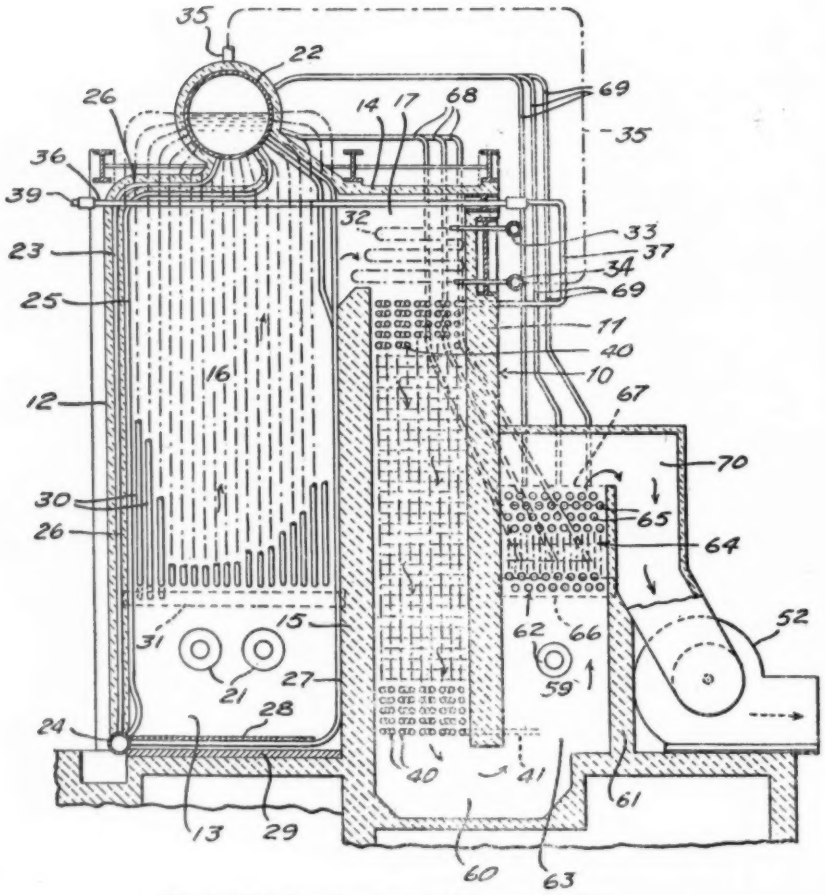


Fig. 1—Combination steam boiler and oil furnace

A combination steam boiler and convection furnace for heating oil, for example, charge stock for a factionation column. It eliminates the need for a separate steam unit to supply steam to the distillation apparatus for revaporization, stripping, and other uses.

A minimum amount of air for combustion and a consequent high efficiency results from the unit without danger of overheating the oil passing through the coils. No heat is wasted; that above the amount necessary for heating the oil is used to produce steam. The unit may be fired by any conventional means.

Boiler tubes are in the primary chamber 16 in Fig. 1. Oil tubes are in the adjoining chamber immediately behind. Additional oil tubes and hot water tubes in the third and smallest chamber utilize any excess heat that would otherwise be wasted.

U.S. 2403432, July 9, 1946, issued to Pell W. Foster, Jr., Englewood, N. J., assignor to Foster Wheeler Corp.

Provides Constant Current for Cathodic Protection System

A combination of a wind-driven generator and a storage battery with automatic controls is used to provide the constant amount of current and voltage necessary for pipeline protection. Specially designed mercury switches and a suitable electric layout are incorporated.

With normal wind conditions, the generator supplies the potential needed. Excess electrical energy generated by high winds is automatically applied to charging the battery, which in turn protects the pipeline when the wind velocity is too low for this purpose.

Corrosion caused by low potential from an old battery or by occasional high potential from a wind-driven generator is thereby eliminated.

U.S. 2402494, June 18, 1946, issued to Ralph E. Hantzsch and Ora C. Mudd, Houston, Texas, assignors to Shell Development Co.

Self-Cleaning Laminated Zinc Electrode Prevents Corrosion

More efficient electrolytic protection against corrosion of storage tanks, condensers, boilers and other refinery equipment is claimed for a new type of laminated zinc electrode. The new electrode, recently patented by two oil company engineers, can be used for the protection of such equipment when it contains electrochemically corrosive solutions.

The usual zinc electrodes are solid, and have the disadvantage of quickly becoming covered with a hard cement-like coating which reduces their efficiency and must be removed mechanically. The new type of electrode is said to be self-cleaning. It is made up of a number of very thin sheets of zinc foil (0.014 to 0.0014 in. thick) held together between two steel

To Meet Your Specific Requirements

DU PONT PETROLEUM CHEMICALS

Backed by Du Pont Research . . .

For additives of quality, designed to meet specific requirements—additives designed to do the job *better*—consult Du Pont. Let us work with you in selecting or developing the *right* product to fit your *particular* needs. The services of our Technical Men, backed by years of practical field and laboratory experience, are available to help solve your problems. For full details, write E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Del.

Tune In: Cavalcade of America—Mondays—NBC Network

CONSULT DU PONT FOR:

Gasoline Stabilizers

•

Oil-Soluble Colors

•

Lubricating Oil Additives

•

Fuel Oil Additives

•

Metal-Working Lubricants

•

Corrosion Inhibitors

•

DU PONT

PETROLEUM CHEMICALS

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING

. . . THROUGH CHEMISTRY

ATTENTION ENGINEERS!

Complete Series in Booklet Form

PROCESS ENGINEERING DATA

This series, comprising 7 articles, deals with the development of improved methods of correlating and predicting fundamental physicochemical data—information important and necessary for efficient design and operation of modern refining plants.

The articles—written by Dr. K. M. Watson and his associates—are a result of studies conducted at the University of Wisconsin as a part of its graduate research program in chemical engineering.

All the articles formerly appeared in the TECHNICAL SECTION of National Petroleum News. Because of their popularity and usefulness, they were reprinted in booklet form.

Here are the subjects covered in the series:

- ***Vapor Pressures and Critical Properties of Organic Compounds***
- ***Thermal Properties of Hydrocarbons***
- ***Thermodynamic Properties of Organic Compounds***
- ***Thermodynamics of Solutions — Ideal Systems at High Pressure***
- ***High Pressure Vapor - Liquid Equilibria***
- ***A Universal Viscosity Correlation***
- ***Pressure Drops in Granular Beds***

This time-saving reference booklet—48 pages, magazine size, complete with tables and illustrations—is attractively and durably bound.

PRICE $1.00*

*(Ohio purchasers, add 3% sales tax)

Mail your order to:

PETROLEUM PROCESSING

1213 West Third Street, Cleveland 13, Ohio

angles. No binding material is used between the layers.

In operation the outer sheets of zinc are attacked first, and as they are eaten away they become perforated and expose the next sheets, which are attacked in turn. The perforations in the first layers plus the formation of scale between the layers combine to remove the remaining portions of the outer sheet. The action is said to be progressive through the entire electrode.

U.S. 2404031, July 16, 1946. Charles H. Bunn, Jr. and Leo W. Schrader, assignors to Standard Oil Development Co.

Aids Accurate Metering Of Volatile Liquids

A means is provided for maintaining the pressure at which volatile liquids and liquefied gases are being metered consistently above the vapor pressure of the material being pumped so that greater accuracy in metering is insured.

A diaphragm or a Sylphon Bellows operated regulatory valve is installed in the flow line from the storage tank through the positive displacement meter as shown in Fig. 2. A control liquid of equivalent or slightly greater vapor pressure than that of the material being metered provides the pressure differential necessary to actuate the control valve.

The control valve 10 and control capsule 13 in Figs. 2 and 3 may be replaced

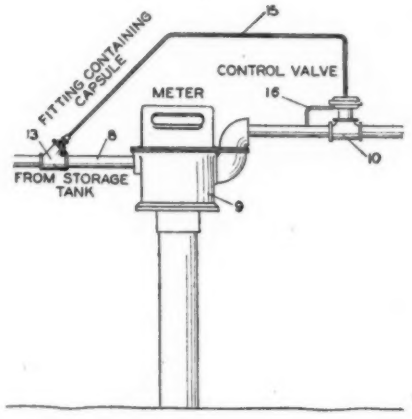


Fig. 2—Control system on meter line

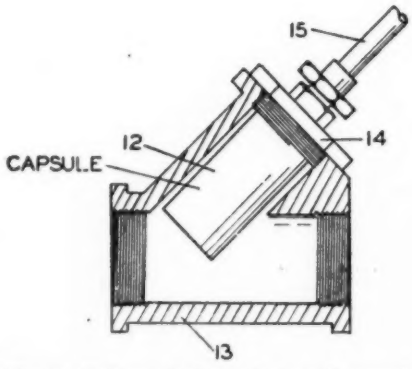


Fig. 3—Enlarged view of control capsule

in the system by the control valve shown in Fig. 4, in which the control liquid is contained in the upper chamber 47 of the valve itself.

U.S. 2402355, June 18, 1946, issued to Thomas H. Whaley, Jr. Bartlesville, Okla., assignor to Phillips Petroleum Co.

Rotates Pipe in Either Direction Without Removal from Pipe

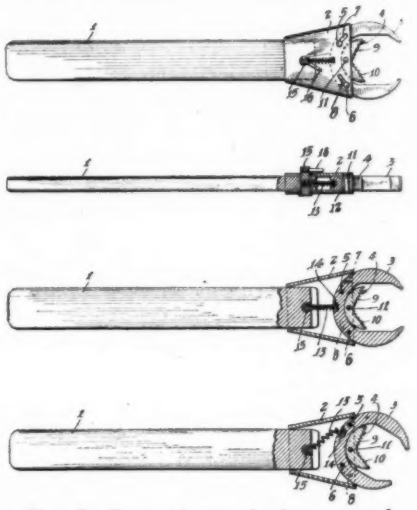


Fig. 5—Four views of pipe wrench

A ratchet-type wrench which will positively grip pipe and rotate it in either direction without being removed from the pipe has been patented by a California inventor.

Advantage over ordinary pipe wrench is claimed because of easy access in cramped quarters without necessity of operator's hands for adjusting jaws. However, the range of pipe sizes which can be handled is limited, whereas standard wrench covers a large variety of sizes.

Fig. 5 illustrates the operation of the movable pipe-encircling member 3 and the stationary jaw member 4.

U.S. 2403187, July 2, 1946, issued to Frank W. Livermont, Los Angeles, Calif., assignor to Richmont, Inc.

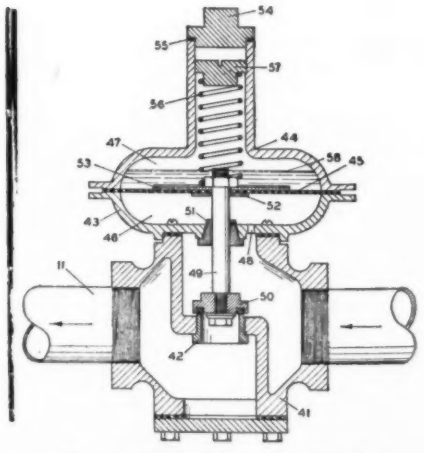
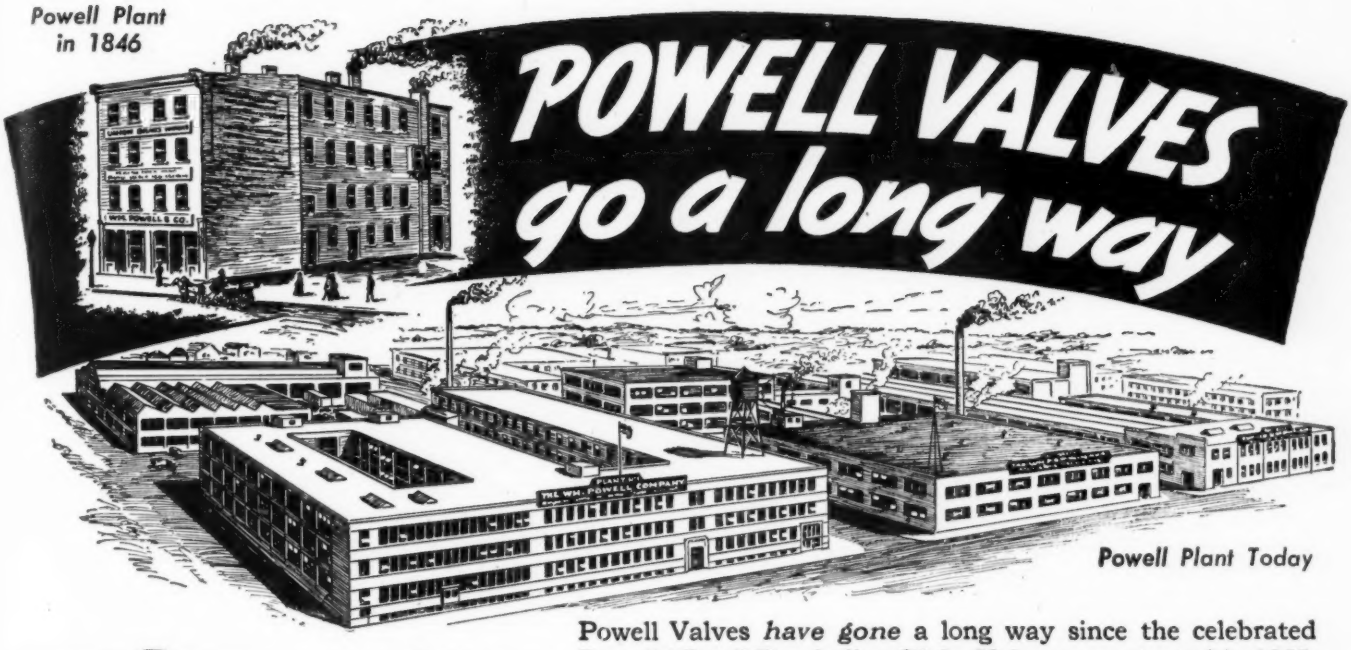


Fig. 4—Alternate control valve

Powell Plant in 1846

POWELL VALVES go a long way



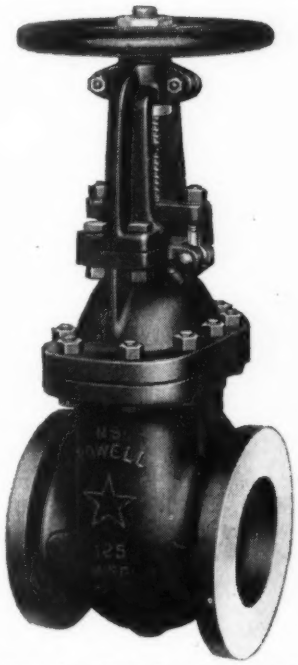
Powell Plant Today

Powell Valves *have gone* a long way since the celebrated Powell "Star" Regrinding Globe Valve was patented in 1865.

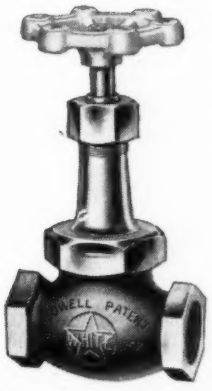
Today, with a notably complete line of valves, which includes every required type, size and design—in bronze, iron, steel and many corrosion-resistant metals and special alloys—Powell Valves *are going* a long way in meeting the flow control requirements of modern industry.

Above all, Powell Valves *go* a long way in actual service, because each valve is designed to give maximum performance under the actual operating conditions it will encounter.

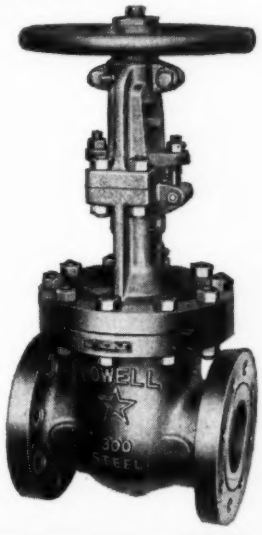
Catalogs on request. Kindly state whether you are chiefly interested in Bronze, Iron, Cast Steel, or Corrosion-Resistant Valves.



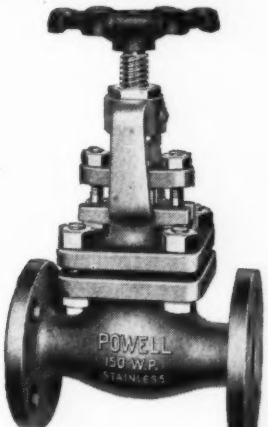
Large Iron Body Bronze Mounted Gate Valve for 125 pounds W. S. P. Made in sizes 2" to 30", incl. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc. Taper wedge double discs can be provided in sizes 2" to 12", incl. Seat rings and stem are bronze. Disc is bronze in 3½" and smaller size valves and bronze faced in the larger sizes. Also available in All Iron for certain services.



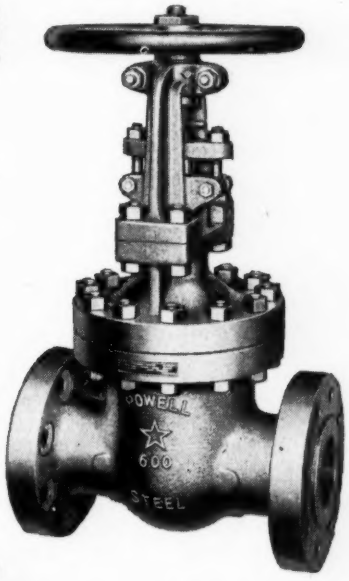
200-pound Bronze Globe Valve. Has screwed ends, union bonnet, renewable, specially heat-treated stainless steel seat and regrindable, renewable, wear-resisting "Powellium" nickel-bronze, plug type disc.



Class 300-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc. Powell Cast Steel Valves of all types are available in pressure classes from 150 to 2500 pounds, inclusive.



Stainless Steel Gate Valve for 150 pounds W. P. Has flanged ends, outside screw rising stem, bolted flanged yoke-bonnet and taper wedge solid disc. This is one of many special Powell designs for handling corrosive media.



Class 600-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged yoke and taper wedge solid disc.

The Wm. Powell Co., Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES

German Aircraft Oils Were Made By Polymerization of Olefins

Condensation of Report of U.S. Naval Technical Mission in Europe, "Manufacture and Application of Lubricants in Germany", by M. E. SPAGHT.

Although the Germans had carried on extensive research work in the manufacture of synthetic lubricating oils, their actual production towards the end of the war was only 1700 b/d, while oils from petroleum were made at the rate of about 15,800 b/d. Their high quality synthetic oils were manufactured by the catalytic polymerization of ethylene and other olefins. Blended with mineral oils, these synthetics were used for aircraft oils.

Other processes included the hydrogenation of brown coal-tar, ester syntheses, naphthalene alkylation, and the polymerization of tetrahydrofuran and ethylene oxide. In addition, an organic tin compound as an oxidation inhibitor, a paraffin ester as a corrosion inhibitor, and two extreme pressure additives were developed.

The petroleum lubes were made by the conventional dewaxing and solvent extraction processes known in this country.

WHILE the bulk of liquid fuels used by the Germans in the war came from synthetic processes, the great part of their supply of lubricants was from petroleum. This crude petroleum came from Germany, Austria, Hungary and Rumania.

The major producers of petroleum lubricants employed dewaxing and solvent extracting. Propane and ethylene dichloride dewaxing processes were employed and furfural, SO_2-benzol, phenol and propane (Duo-sol), and propane alone for solvent extraction.

The bulk of the oil from petroleum was refined to a Viscosity Index between 80 and 100, except for the medium and low VI industrial lubricants. Because of the good native quality of the lube fraction in the crudes, the production of high VI products did not entail large losses to selective solvent extracts. For example, in the refining of Zistersdorf (Austria) crude, the final yield of deasphalted, dewaxed, solvent extracted, acid treated, clay filtered lubricating oil was 50% by weight of the gas oil free residue from the crude topping units.

An approximate breakdown of the German supply of lubricating oils from both petroleum and synthetic sources is given in Table 1. Taken from about 1942, the figures are from documents and from interviews with an official of the oil planning board of the German government. The supply of oils in 1943 may have exceeded these figures somewhat because of the huge construction program initiated then and still going on in 1944 when it was revealed by the Allied bombing raids.

The major part of the volume of synthetic lubricants available to the Germans went to aircraft oils. The oil used by the Luftwaffe was normally a mixture of equal parts of synthetic and highly refined mineral oil, without additives or inhibitors.

Except for the use of Rheinpreussen synthetic oils in diesel engines by the German navy, engines other than aircraft used refined mineral oils. Gasoline and diesel engines were supplied with the same grades with no special additives. German oil and engine people agree in general that well refined mineral oils were adequate for diesel requirements.

The German Wehrmacht used two grades of motor oil. The winter grade had a viscosity of about 52 S.S.U. at 210 F. and a VI of about 100, while the corresponding values for the summer grade were 62 and 95. The great difficulties encountered in Russia in the winter of 1941-42 with cold starting of trucks and tanks was an impetus to the synthetic ester oil development discussed later in in this article.

Specifications and properties of the components and the blended German aircraft oil are shown in Table 2. The data shows that the synthetic component is much more viscous than the mineral oil component. Because this property is easily controlled, the viscosity of the synthetic product was kept high so that bright stock (high viscosity fractions) could be released for industrial purposes.

The low temperatures in the war campaign required the lowering of the pour point of lubricants for almost every application. Special problems, all solved with synthetic products, were low temperature lubricants for torpedoes and other weapons, a water-soluble oil for torpedoes and a journal oil for the railroads. Normal automotive and industrial oils were apparently little different from those used in America.

Mixed Polymerization Process

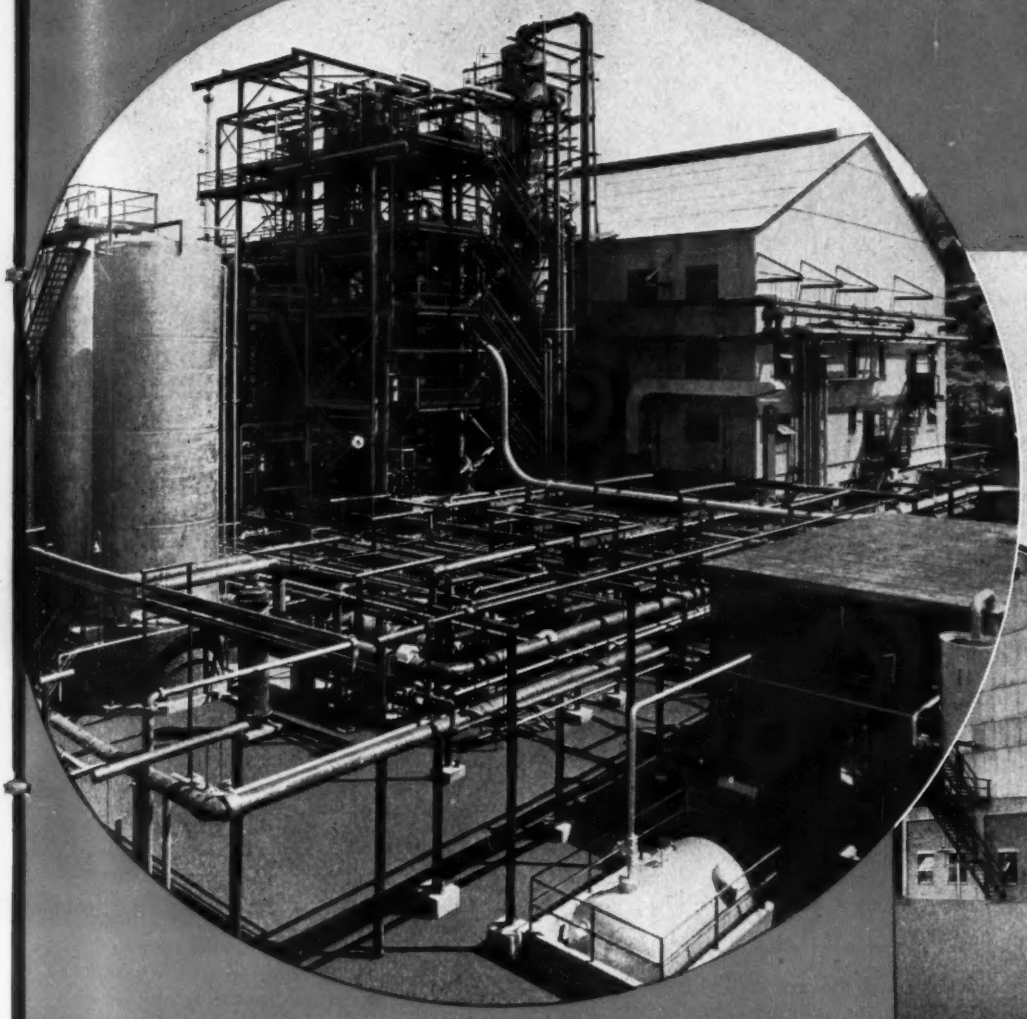
A new synthetic process involving mineral oil lubricating fractions and called mixed polymerization was developed by I. G. Farbenindustrie. In this process a deasphalted and dewaxed but not solvent

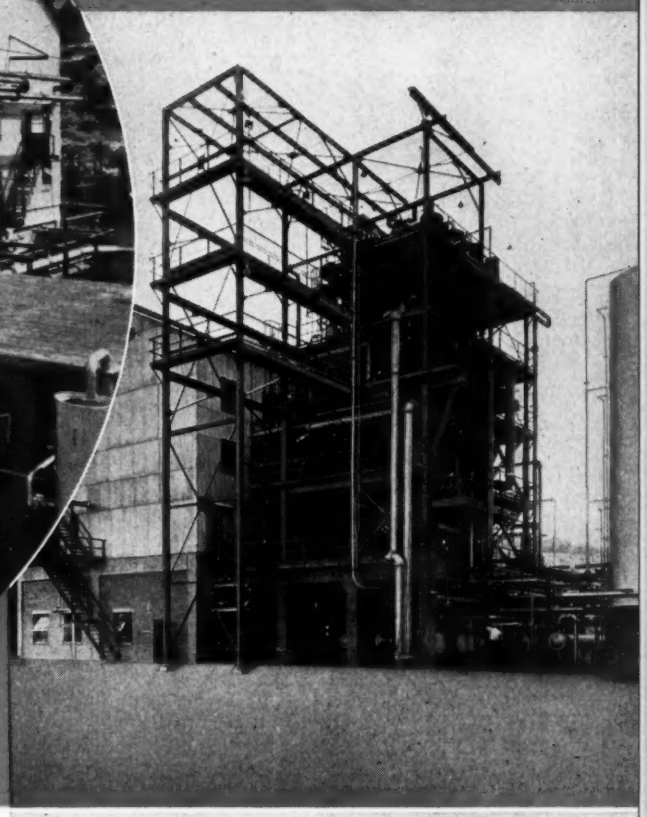
TABLE 1—Supply and Disposition of German Lubricating Oils in 1942

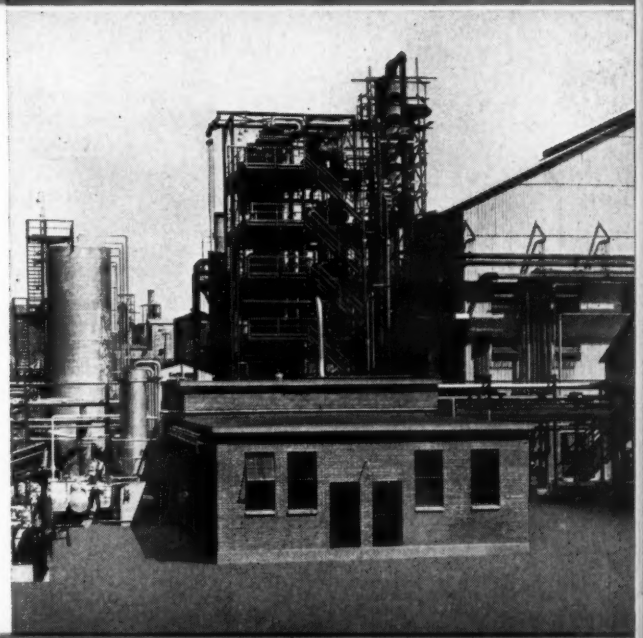
Supplier	Methods of Manufacture	Supply B/D	Disposition: Aircraft B/D	Disposition: Other B/D
Various refiners	Conventional Refining Methods	15,750	750	15,000
Brabag Zeitz	TTH Hydrogenation of Brown Coal Tars	600	...	600(1)
Politz	Olefin Polymerization	250	250	...
Rhenania Ossag	Olefin Polymerization	200	200	...
Ruhrchemie	Olefin Polymerization	200	...	200(3)
Rheinpreussen	Aromatic-Parrafin Condensation	50	...	50(3)
I.G.-Leuna	Ethylene Polymerization	300	300	...
I.G.-Leuna	Ester Synthesis	100	100	...
	Totals	17,450	1600	15,850

(1) Relatively low quality, used for industrial and automobile lubricants.
(2) Used by Army for trucks, tanks, etc.
(3) Consumed entirely by German Navy for diesel engines.

UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION







M·E·K SOLVENT DEWAXING PLANT

The photos on this page show three views of a 2000-barrel M · E · K Solvent Dewaxing Plant recently designed, engineered and constructed by Arthur G. McKee & Company under a Texaco Development Corporation process license.

Arthur G. McKee & Company

★ *Engineers and Contractors* ★

2300 CHESTER AVENUE · CLEVELAND, OHIO

30 ROCKEFELLER PLAZA, NEW YORK, N. Y.

460 McCORMICK BUILDING, CHICAGO, ILLINOIS

extracted lubricating oil distillate is reacted in the presence of $AlCl_3$ with about an equal part of a synthetic polymer of ethylene or other olefins, such as are obtained from thermal cracking of waxes. An oil of superior quality, the yield exceeds substantially that which could be obtained by mixing the olefin polymer and the mineral oil fraction after such solvent extraction that the mixture would have the same VI as the products of mixed polymerization.

I. G. worked out an application involving such treatment. To prepare 1 volume of oil meeting aircraft specifications by solvent extraction, 1.5 parts of deasphalted and dewaxed distillate were needed. This would require discarding 0.5 parts as extract. However, by mixed polymerization of the 1.5 parts of distillate with 1.5 parts of ethylene polymer, an approximate 3.0 volume yield could be obtained equal in quality (both by laboratory and full-scale engine tests) to either the ethylene polymer itself or the solvent extracted fraction. Thus, 0.5 volumes of low grade extract could be made into aircraft oil increasing the yield from 2.5 to 3.0 volumes.

Ethylene is first polymerized with $AlCl_3$; the resulting mixture, containing about 5% $AlCl_3$, is mixed in an autoclave with an equal weight of mineral oil, being agitated 3 to 4 hours at 210 to 250° F. The reaction is primarily between aromatics (and any olefins present) in the oil and the olefin polymers of ethylene. The product is then freed of $AlCl_3$ and neutralized. Fractionation may or may not be necessary, depending on whether any low boiling components entered the ethylene polymerization system. The process is claimed to yield oils superior in ring-sticking performance to a mixture of the ethylene polymer and a heavily extracted mineral oil raffinate. Some yield and analytical data on this treatment of a fraction of Hauskirchen crude oil are given in Table 3.

In 1943 the German government ordered I.G. to build plants at Leuna, Heydebrek, and Moosbierbaum to produce about 1500 b/d of aircraft oil by this process using ethylene as the olefin raw material, but none of the plants were completed[1].

The TTH Process

This was a mild high pressure hydrogeration of brown coal tar. Instead of gasoline as the net product, as is the case with most coal and coal-tar high pressure hydrogenations, this process is milder and yields large volumes of diesel fuel, lubricating oil, and wax. In the only commercial installation, the Brabag plant in Zeitz, the product had a VI of 50 to 60. Separated from the hydrogenation product and with no further treatment, it was sold for use as motor oil[2].

Polymerization of Olefins

Most of the synthetic lubricants were produced by polymerization of low boiling olefins in the presence of $AlCl_3$ to compounds boiling in the lubricating oil range. Two different applications of the process existed: one developed by I.G. using ethylene, and one used by Ruhrchemie, Rhenania Ossag, and Politz (Stettin), employing a mixture of olefins boiling in the 80 to 570° F. range. The products are chemically and in performance very similar. I.G. technologists maintained that oils of higher viscosity can be prepared from ethylene than from the olefin mixture. They believe that under normal economic conditions ethylene would be the preferred olefin.

Their choice of ethylene may have been due in part to their particular company position. As operators of coal and tar hydrogenation processes, they could perhaps make low boiling olefins more readily than higher boiling ones of the same quality. Both applications are described:

(A.) Ethylene Polymers

The I.G. organization at Leuna gave considerable thought to the fundamental questions underlying the synthesis of a high quality lubricating oil. It was believed that a molecular type should be chosen which contains the maximum number of desired lubricating properties and that a synthesis for that molecule should then be developed. The basic requirements for a good lubricant are high VI, low pour point, good lubricity or "oiliness," and stability. I.G. believed that a molecule could be designed which would satisfy all except perhaps lubricity and that additives could be considered to improve that property.

For high VI, a paraffin consisting of long side chains on a central structure, or an aromatic or naphthene nucleus with long paraffin chains, should be the preferred forms. To obtain low melting compounds, and thereby a pour point which corresponds simply to a high viscosity, disymmetry within the individual molecules was found necessary. To produce good lubricity, or lubricating qualities, the molecule must be able to adhere to the surface it is lubricating. This may be supplied by molecules of "strained" carbon configurations or combined oxygen, nitrogen, or sulfur atoms in particular arrangements, or it may be supplied by an additive. To approach good stability, a paraffin was chosen and the aromatics ruled out.

In setting out to synthesize paraffin molecules in the lubricating oil range, the polymerization of many low boiling olefins was studied. Propylene alone could never be made to give a product of higher than 70 to 80 VI (I.G. found that by incorporating 1 to 2% of polystyrene in the polymerization feed, propylene would yield oils with a VI above 100. This fact was observed several years ago but was not further developed, presumably be-

TABLE 2—Properties of German Aircraft Oil and Its Components

Properties	Air Ministry Specifications for Aircraft Oil	Typical Syn. Oil from Olefin Polymerization	Typical Rfd. Mineral Oil Fraction	Typical Mixture Equal Parts of Synthetic & Mineral
Density at 68° F.	0.895 max	0.84	0.89	0.875
Vis., S.S.U. at 212° F.	95 min.	215	57	135
Vis., S.S.U. at 122° F.	580—660	1450	250	590
Viscosity Index	98 min.	120	98	110
Pour Point, ° F.	—4 max.	—7	±0	—13
Flash Point, ° F.	437 min.	604	437	464
Fire Point, ° F.	437 min.	670	500	534
Conradson Carbon, % wt.	0.25 max.	0.38	0.16	0.22
Ash Content, % wt.	0.01 max.	0.001	0.00	0.001
Neutralization Number Mg. KOH/g.	0.06 max.	0.03	0.03	0.03
Saponification Number Mg. KOH/g.	0.2 max.	0.11	0.11	0.08

TABLE 3—Mixed-Polymerization of a Lubricating Oil Distillate from Petroleum

	Deasphalted & Dewaxed Petroleum Distillate	Ethylene Polymer	Mixed-Polymer equal parts C_2H_4 Polymer and Petroleum Distillate
Input, parts by wt.	52.5	47.5(1)	
Output, parts by wt.	....	....	93.5(2)
Density at 68° F.	0.915	0.855	0.870
SSU at 100° F.	540	2950	1200
SSU at 210° F.	58	205	108
Viscosity Index	54	109	108
Flash Point, ° F.	428	428	428
Pour Point, ° F.	±0	—22	—22
Conradson Carbon, % wt.	1.09	0.08 (est)	0.15

(1) The input is expressed as the amount of ethylene polymer of this quality that would have been produced by the ethylene charged. To produce 47.5 weights of this polymer oil, 63.3 weights of ethylene is required.
(2) In addition, 5.1 weights of low molecular weight material is produced.

(1) The following documents transmitted to the U. S. Navy Bureau of Ships relate to this process:

"Ueber das Prinzip der Schmierol-Mischpolymerisation" (I. G.-Leuna-Aktennotiz, Jan. 12, 1942)

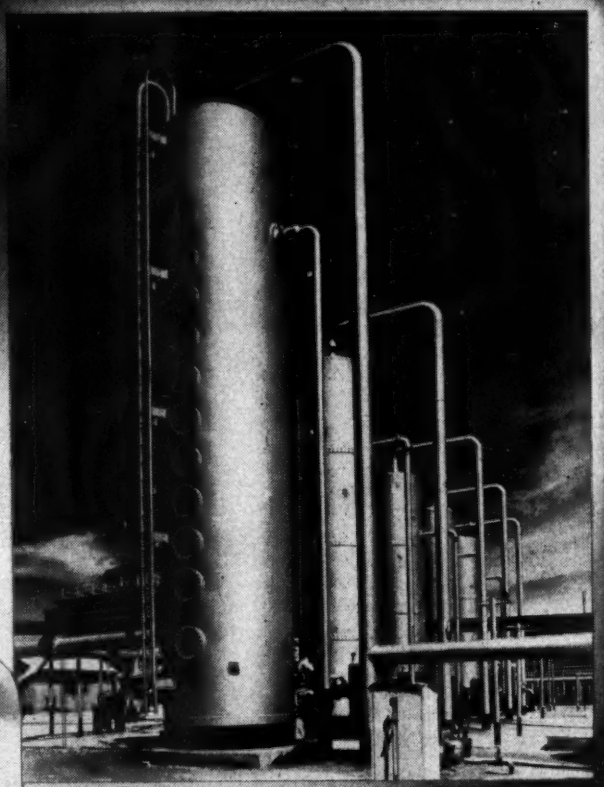
"Mischpolymerisation von SS-01 mit Mineralol" (I.G.-Leuna, Feb. 1, 1943)

"Herstellung von Flugmotorenol durch Mischpolymerisation" (I.G. - Leuna - Bericht, March 29, 1943)

(2) Fully described in report of U. S. Technical Mission, "Production of Synthetic Fuels by the Hydrogenation of Solid and Liquid Carbonaceous Materials".

Check V These Benefits of WARREN'S Stabilized NATURAL GASOLINE

and LIQUEFIED PETROLEUM PRODUCTS



NATURAL GASOLINE
Chemical Grade
HYDROCARBONS
Iso-Pentane
Normal Butane
Iso-Butane
Propane
Hexane
STA-VOL-ENE

For

- ☑ VOLATILITY
- ☑ HIGH OCTANE
- ☑ QUICK STARTING
- ☑ ANTI-KNOCK
- ☑ CARBON FREE
- ☑ UNIFORM QUALITY

WARREN PETROLEUM CORPORATION

Manufacturers, Exporters and Marketers of Natural Gasoline and Liquefied Petroleum Gas

Tulsa, Oklahoma

Export Terminals: Corpus Christi, Port Arthur, Baytown, Texas City, and Norsworthy, Houston, Texas; Lake Charles, La.; Marcus Hook, Pa.

cause styrene produced oils with unsatisfactory stability. Polystyrene gave the same improvement in VI to polymers of other olefins). Isobutylene gave products with high VI but with poor lubricity. Normal olefins like octylene-1, however, gave high quality polymers and were the type used by Ruhrchemie, Rhenania-Ossag, and Politz. Due in part at least to its supply, I.G. preferred to concentrate on gaseous olefins.

Others had polymerized ethylene but never obtained a product with a VI above zero. Through extensive research, I.G. found that by careful selection of feed stock and operating variables, the VI could be raised to about 120. Polymers up to about 300 S.S.U. at 210° F were made in yield equal to 78 to 80% by weight of the ethylene feed, and with pour point of —30° F. Lubricating qualities were roughly equal to those of high quality mineral oil, hence, satisfactory for most general uses.

Regarding stability, these materials absorbed oxygen without much alteration in properties. In fact some of the oxidized molecules were found to be very good lubricants, actually better than the original polymer and quite stable. In use, the viscosity of the material at first increased noticeably (about 33%), but then leveled off with no additional change.

Production began in 1937 at 15 b/d, and reached a total of 325 b/d by 1944. Future plans were for a goal of some 925 b/d. Since 1941, all ethylene polymer had been made to about 220 S.S.U. at 210° F. and had been used in equal volume with highly refined mineral oil for aircraft oil. It showed up very well in the ring-sticking test, which was widely used as a specifications measurement for aircraft oils.

German Air Ministry specification was a minimum ring-sticking time of 8 hours. Mineral oils normally just reached the minimum, but the ethylene polymers ran 20 hours and longer.

In addition to the main polymer products of the two processes, in either operation a small volume (about 10% of the total yield) of a 60 to 100 S.S.U. at 122° F. fraction was recovered by product fractionation. This material was highly valued as a lubricant for jet aircraft. It had a pour point of —95 F, and was mixed with other ingredients to produce various lubricants for low temperature operation. An ingredient for a journal lubricant used by the German railroads was recovered by hydrolysis of the $AlCl_3$ sludge produced in the polymerization.

Table 4 shows typical yield and quality data for the operations producing both viscosity grades of ethylene polymers.

To obtain high viscosity and high VI products, the ethylene raw material should be a minimum 95% pure. An inert content above a few per cent disrupts the chain formation and prevents polymerization from forming the high viscosity products. Presence of CO_2 is very serious; unless this contaminant is almost entirely absent, polymerization will not occur. (Reaction with CO_2 apparently seals off the olefin chains). Up to 0.005% can be tolerated. Nitrogen (as ammonia), sulfur and oxygen are also poisons and should be completely removed. A few per cent of propylene can be tolerated but above 5% the quality of the product (especially VI) begins to decrease.

Polymerization is a batch process and proceeds in two steps, first the catalyst preparation, and second the polymerization itself. A stirred autoclave (carbon steel) of about 30 bbls. capacity was used at Leuna. Into this was first run about 400 gal. of a recycle oil, which was a 260°-520° F. fraction separated from the polymerized product. This oil was used as a slurry oil for 275 lbs. of $AlCl_3$ (5 to 6% of the ethylene charge). (The $AlCl_3$ used normally contained 2 to 4% by weight of $FeCl_3$ to limit the activity).

Ethylene gas was then introduced until a pressure of 30 atmospheres had been established. The temperature was then raised to 160° F. by means of hot water coils. Polymerization began and the temperature rose rapidly to 360 to 430° F. Cooling water was then put through the coils to bring the temperature down to 230 to 250° F., the operating level, ending the catalyst preparation step. The ethylene pressure had dropped practically to zero, and the product of this step was a catalyst compound of $AlCl_3$ and polymerized ethylene. The temperature to which the system rises during this step determines the activity of the prepared catalyst; the higher this peak temperature, the less active the catalyst.

Ethylene is then introduced as a vapor at the maximum rate possible while maintaining the desired temperature level. This rate is governed only by the ability of the cooling system to remove the heat of reaction. As the reaction proceeded, the catalyst would begin to lose activity so that a steadily increasing pressure of ethylene was used to consume the system's heat removing ability. At the end of six hours, ethylene pressure had risen to 20 to 30 atm., and a total of 4800 lbs. of C_2H_5 had been reacted. Catalyst was considered spent at that point; further use of it resulted in depreciated product.

For a more viscous oil, a very active catalyst with lower peak temperature (360° F.), and lower operating temperature (230° F.) was used. For a less viscous grade, a less active catalyst, peak temperature of 430° F., and operating temperature of 250° F. was employed.

After the polymerization, the $AlCl_3$ was separated by centrifuging, and methanol extraction. The oil was then neutralized and fractionated, producing recycle oil, a low viscosity fraction (normally boiling up to about 660° F.), and the main polymer oil as a residual, which was treated with bleaching earth and filtered.

The centrifuged $AlCl_3$ sludge was hydrolyzed yielding an oil phase which was further polymerized by an $AlCl_3$ stage of treatment and made into a low temperature railroad journal lubricant. A typical weight balance for the polymerization step is shown in Table 5[3].

TABLE 5—Weight Balance for Batch Polymerization of Ethylene

Input	Pounds	Percent
Ethylene	4860	100.0
(Recycle Oil)	(2650)	...
Total Input	4860	100.0
Output		
Polymerized Lubricating Oil Product	3690	75.9
Low Viscosity Distillate Oil Fraction	330	6.8
Oil from $AlCl_3$ Sludge Hydrolysis	360	7.4
(Recycle Oil)	(2650)	...
Unreacted Ethylene	130	2.7
Treating Losses, etc.	350	7.2
Total Output	4860	100.0

(B). Higher Olefins Polymers

Another synthesis using olefins boiling in the 80 to 570° F. range was practiced by Ruhrchemie in Holten, by Rhenania-Ossag in Hamburg-Harburg, and at the Politz refinery near Stettin.

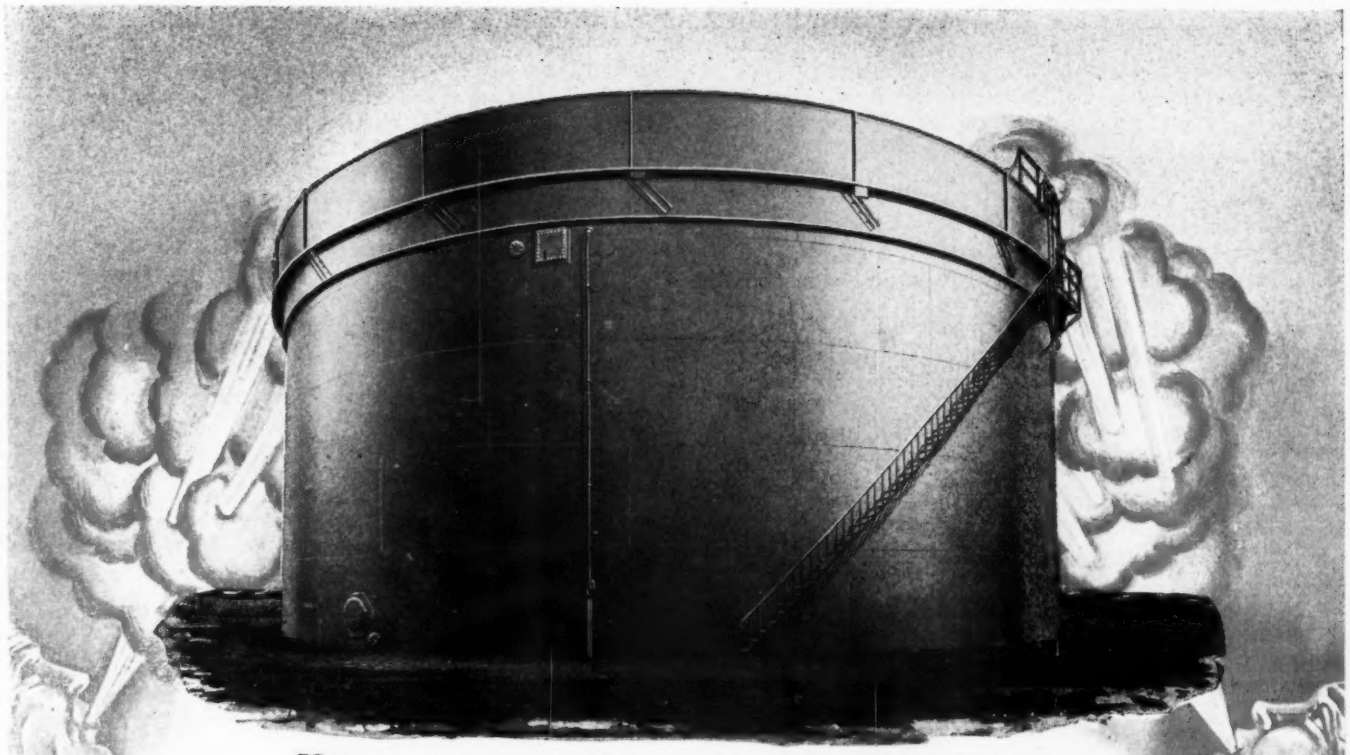
At Ruhrchemie, a 360 to 600° F. fraction from the Fischer-Tropsch plant was cracked thermally at 1020 to 1110° F. The 85 to 360° F. fraction was separated out as a polymerization feed. The ultimate yield of this feed was 60% by weight of the thermal cracking charge. It contained 60 to 70% olefins, largely normal alpha compounds; the naphthene content

(3) Following document transmitted to Bureau of Ships, relates to ethylene polymerization: "Das Athylen Schmierol Verfahren" (I.G.-Leuna Dr. H. Zorn report of July, 1943)

TABLE 4—Typical Yields and Properties of Ethylene Polymers

	Low Vis. Polymer Product	High Vis. Polymer Product	Low Vis. Distillate Oil Fraction	Oil from $AlCl_3$ Sludge by Hydrolysis
Yield, % wt. of charged ethylene	....	76.0	6.8	7.2
Yield, % wt. of charged ethylene	ca. 70	....	ca. 10	ca. 10
Density at 68° F.	0.850	0.853	0.817	0.857
S.S.U. at 100° F.	1050	3200	44	1170
S.S.U. at 210° F.	106	215	....	106
Viscosity Index	124	111	....	107
Pour Point, ° F.	—36	—33	below —100	—35
Flash Point, ° F.	375	446	293	356
Conradson Carbon, % wt.	0.08	0.08	0.01	0.20
Molecular weight *	640	825	ca. 250	325

* Determined by boiling point elevation method



"RAISING THE ROOF"

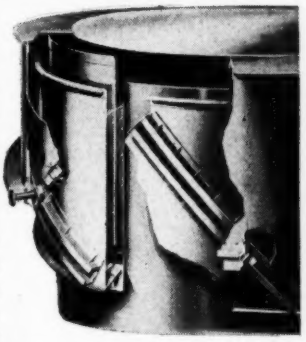
can be a profitable proposition . . . if it's

A HAMMOND VAPOR-LIFT

What to do about breathing and filling losses has always been a problem with cone roof tanks . . . many operators believe there is little that can be done or that it doesn't pay to do anything about it . . . not so with the owners (a major company) of this Hammond ***Vapor-Lift*** Tank which they had built and connected with three cone roof tanks . . . now there is no loss from breathing or filling . . . and the ***Vapor-Lift*** Tank will pay for itself in a very reasonable period of time.

The ***Vapor-Lift*** Tank has full liquid storage capacity and in addition the roof raises itself everytime the vapor pressure increases and lowers itself as the vapors diminish . . . it is the "lung" which stores the vapors generated in the three cone roof tanks. Without this ***Vapor-Lift*** Tank the vapors formed in the three cone roof tanks would be exhausted into the atmosphere with an attendant loss in quantity as well as quality.

Hammond ***Vapor-Lift*** Tanks can be built to capacities of 100,000 barrels to provide a variable vapor space of ample capacity to permit the expansion or contraction of vapors, to eliminate tank breathing losses, reduce filling losses and maintain the quality of the stored product in one or a number of cone roof tanks.



The simple mechanism, which directs and stabilizes the upward and downward movement of the roof, consists of nothing but a track placed at regular intervals at an angle of 45 degrees; a roller guide rides in this track and other roller guides, placed at 90 degrees to the rollers in the tracks, ride against the side of the tank and take any lateral load such as from high winds. The bearings of the roller guides are self-lubricating to minimize maintenance and repair. This simple stabilizing mechanism prevents binding of the tank roof even under conditions of unequal loads caused by snow, ice, settled tank foundations, etc.

HAMMOND
IRON WORKS
Warren, Pa.

NEW YORK • BOSTON • PITTSBURGH • AKRON
DETROIT • CLEVELAND • CINCINNATI • RICHMOND
CHICAGO • ARGENTINA; "TIPSA", BUENOS AIRES

HAMMOND designs, fabricates and erects tanks of all types for liquid and dry storage . . . above or below ground . . . high or low pressure . . . cone roof . . . HAMMOND SPHERE . . . floating roof . . . VAPOR-LIFT . . . spheroid . . . GLOBE ROOF PRESSURE . . . gas holder . . . also stainless and stainless-clad vessels of all types and designs for the petro-chemical industries.

was only a few per cent and the aromatic content was "extremely low."

At Rhenania-Ossag, the polymerization raw material was prepared by cracking paraffin wax from Austrian crude oil at low pressure and 1040 to 1100° F., yielding a 60% by weight of liquids above C_4. Highly olefinic, this liquid was best suited for synthesis if the wax from which it was prepared was low in oil content. A fraction boiling from 85 to 590° F. was separated for polymerization feed.

Politz also used Austrian waxes, cracking them at low pressure and 910 to 950° F. A fraction boiling from 95 to 570° F. was separated and the heavier components recycled to extinction. Based on the raw feed, yield in this process of polymerization feed was 70%.

In all cases, polymerization was carried out in a stirred autoclave at 140 to 175° F.; $AlCl_3$ equal to about 6% by weight of the feed was added, and the reaction required 15 to 20 hours. Rhenania began at room temperature, raised to 175° F. after five hours, and the reaction took seven hours longer. Approximately 95% of olefins were converted, and of this polymer about 75% was recovered as primary product. A low viscosity spindle oil was normally separated. In addition, Politz prepared a cylinder oil by hydrolysis of the $AlCl_3$ sludge.

Both Rhenania and Politz used fresh $AlCl_3$ for only one batch. Ruhrchemie, however, used a mixture of sludge from the previous batch and added one % weight of fresh $AlCl_3$, repeating the process for 60 batches before discarding the total sludge and starting with fresh $AlCl_3$.

The Rhenania and Politz oils were quite similar to the ethylene polymers and were used in the same manner—mixing with mineral oils for aircraft lubricants. The main product at Ruhrchemie was a less viscous material and was sold exclusively to the Army for motor vehicles and tanks. Although paraffin wax cracking was the main supply of olefins, plans were shown for direct production from CO plus H_2 synthesis.

Condensation of Aromatics and Paraffins

At Rheinpreussen the technologists argued that the lubes from the Fischer-Tropsch sources were not satisfactorily stable. They pointed out that Pennsylvania oils, their standard for stability, contained some aromatics and hence aromatics need not be avoided. Further, Rheinpreussen had large coal and coal tar operations, and therefore was receptive to any developments that would supply new uses and outlets for aromatics.

The main product of Rheinpreussen was a diesel oil of 570 S.S.U. at 122° F., others were spindle, turbine, and steam cylinder oils of 250 S.S.U. at 210° F. The diesel oil was superior to mineral oil. No direct comparison with the polyethylene was available, but it was generally acknowledged that Rheinpreussen products were poor aircraft oils.

The process was carried out in two stages. In the first, a 430 to 660° F. fraction of Fischer-Tropsch product oil is chlorinated (without a catalyst) at a temperature of 160 to 210° F. for several hours. At the end of the reaction period, it contains about 18% by weight of chlorine (a little more than one chlorine atom per molecule).

In the second stage, the chlorinated paraffin is reacted with naphthalene in the presence of gasoline as a diluent and $AlCl_3$ plus aluminum metal (shavings) as catalyst. The naphthalene supplied was 10% in excess of a one-to-one molal ratio with the paraffin present, but slightly less than a one-to-one equivalent ratio with the combined chlorine. The $AlCl_3$ consumption is about 0.2% weight based on the polymerized product. The reaction is carried out in a stirred reactor at 250° F.; a time of 2½ to 3 hours is required until no combined chlorine remains in the oil. The product oil is separated, neutralized, treated with clay, and fractionated[4].

Synthetic Esters

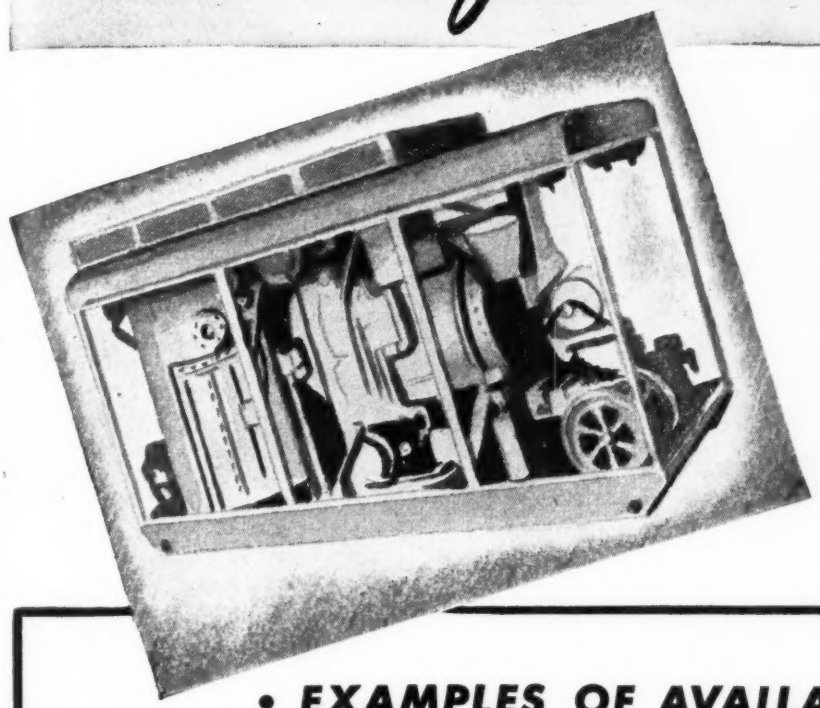
Development of a better lubricant was soon found to be in order. What was needed was one which would result in lower friction in the range of hydrodynamic lubrication, and one which would behave somewhat as an extreme pressure lubricant in the range of boundary lubrication. This property should be combined if possible with high VI, low pour point, and resistance to oxidation and decomposition. After consideration of many types of organic compounds, a long-range program of research on esters was decided upon. The final result was a diester of adipic acid and normal C_8 alcohol. Several types of alcohols and adipic acids were used.

I.G. had a small production of esters which was in great demand during the war campaign in Russia, where failure of machines due to high viscosity of the lubricants in the winter was a very serious problem. An ester of adipic acid and 280 to 360° F. alcohols was used in 50% concentration in an oil for lubricating weapons. An ester of adipic acid and 320 to 390° F. alcohols was used as an ingredient of low temperature lubricant for railroad journals. A special hydraulic lubricant for aircraft contained 5 to 10% of an ester of adipic acid and cyclohexanol. The main volume was for some aircraft lubricating oils, where esters of adipic acid and 360 to 570° F. alcohols were used in 25% concentration.

The I.G. esterification operation is quite simple and does not require unusual purities of raw materials. The acid and alcohol are pumped into a stainless steel lined, agitated reactor. Benzene or naphthalene sulfonic acid is used as a catalyst.

Your Lubricants Will "Weather"
EXTREME HEAT—or COLD—With
ANHYDROUS
METASAP STEARATE BASES
Comparative tests show (photograph A) separation of soap from oil in Lime Greases because of moisture evaporation under heat . . . while clear-type, anhydrous Metasap Stearate Base Greases (photograph B) maintain their oil-base balance under similarly high temperatures because they have no moisture to evaporate. Metasap base greases resist cold, too—their moisture - freedom means no freezing. Metasap gives your lubricants less base, more mineral oil—the true lubricating ingredient. Any desired degree of body from stiff, short - feathered greases to thin fluid lubricants. Write for full particulars.
A
B
METASAP
CHEMICAL COMPANY
HARRISON, N. J.
CHICAGO
CEDARTOWN, GA.
BOSTON
RICHMOND, CALIF.
METASAP CHEMICAL COMPANY
REG. U. S. PAT. OFF.
Stearates
of Aluminum · Calcium · Lead · Zinc

Water Purification EQUIPMENT



Small communities, plants, resort hotels, owners of private water systems and others who have been forced by war conditions to delay purchase of water purifying equipment may now get the needed units in a hurry and at low cost. Nearly $1,500,000 worth of this equipment has been declared surplus and is ready for delivery. This equipment, most of it unused, was built to rigid government specifications for use in Army and Navy installations all over the world. The units and accessories are suitable for installations which would normally call for expenditures from $1000 to $70,000—but in this instance the cost of the equipment will average considerably under normal expenditures. Crating to be done by purchaser. To purchase this equipment, simply call your nearest W.A.A. Regional Office.

• EXAMPLES OF AVAILABLE TYPES •

CHLORINATOR, Ser. No. L6938 w/accessories, Wallace & Tiernan Model type MXV-M, Rated capacity 0.6 lb. to 25 lb. per 24 hour, operating pressure 25 lb. to 250 lb. per hour. Floor base mounting. Estimated water treatment output 4,000,000 gallons.

CHLORINATOR, gauge and indicator stand, Serial No. J-1034. Attachments—hose with stopcock. Mfd. by Wallace & Tiernan. Present location Charleston POE, Charleston, S. C.

Everson Semi-Automatic Manual control vacuum solution feed type SterElator, Series 2900-4A, Type "S", equipped with a Naparion Orifice Motor having a 10 to 1 ratio, with metering capacity range of 1 lb. to 10 lb. of Chlorine Gas per 24 hrs., stationary. Equipment—185′ of chlorine solution hose, hard rubber nipple at end, and ⅛″ steel welded twist link chain, also 10′ of drain hose and 15′ of vent hose, with necessary spare parts for meter, gas regulator and valves; auxiliary tank valve, chlorine pressure gauge; set tools; one solenoid-operated water valve. One Howe No. 130 platform scale, 500# capacity; and one Taylor Enslow slide Comparator for determining chlorine residual. Mfd. by the Everson Mfg. Co., Chicago, Illinois.

HYPOCHLORINATOR, electrically operated, injector type, complete. Serial No. L-7162, including 1 Wallace & Tiernan comparator with prism, 1 chlorine disc and 100 CC bottle Ortho Tolidine solution and 1 30 gal. crock.

CHLORINATOR, vacuum type, dry feed manual control, 15 gal. reservoir, model B-15 No. 108 stationary, floor space required, 6 sq. ft., The McKay Co. With attached motor elec., belt driven, ¼ HP 115, w., 38 amp., 1725 RPM, G.E. Model 5 Kc, L7AB4909.

CHLORINATOR, Manual control, solution feed vacuum type, 40 lbs., 24 hrs., Wallace & Tiernan Mfg., Model type MSVM, Ser. No. K-1911, Complete, less scales. Wt. 400 lbs. Div. Equipment No. LA 100,342.

ALL ITEMS SUBJECT TO PRIOR SALE

All machines are sold under existing priority regulations. VETERANS OF WORLD WAR II are invited to be certified at the War Assets Administration Certifying Office serving their Area, and then to purchase the equipment offered herein.

EXPORTERS: Most surplus property is available to the export market. Merchandise in short supply is withheld from export and if such items appear in this advertisement they will be so identified by an asterisk.

WAR ASSETS ADMINISTRATION

Offices located at: Atlanta • Birmingham • Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Fort Worth • Helena • Houston • Jacksonville • Kansas City, Mo. • Little Rock • Los Angeles • Louisville • Minneapolis • Nashville • New Orleans • New York • Oklahoma City • Omaha • Philadelphia • Portland, Ore. • Richmond • St. Louis • Salt Lake City • San Antonio • San Francisco • Seattle • Spokane

GOVERNMENT OWNED SURPLUS

650

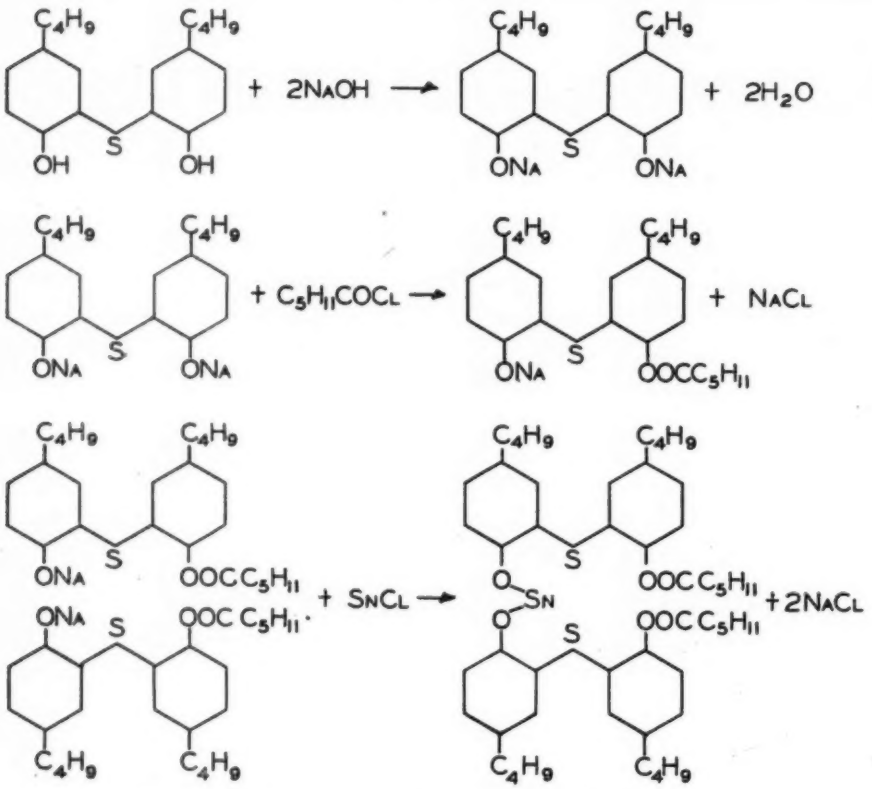


Fig. 1—Synthesis of an organic tin oxidation inhibitor

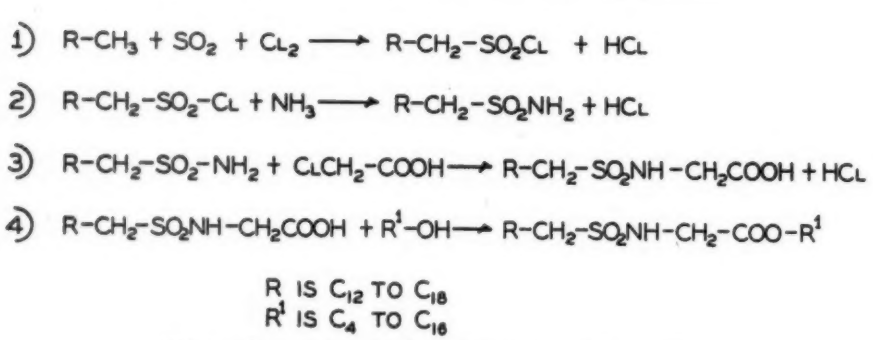


Fig. 2—A corrosion inhibitor from a normal paraffin

about one % weight of the total mixture being required. A 10% stoichiometric excess of alcohol is used. The temperature is 300 to 360° F. During the reaction, the water formed continually distills off, and progress of the reaction is judged by the rate of evolution of water. The reaction requires about 24 hours.

The product is washed with water and soda which removes the catalyst, unreacted acid, and half esters. It is next distilled to remove alcohol and low boiling secondary products. The ester oil then is contacted with 0.5% weight bleaching earth at 160 to 175° F. and filtered. The product thereafter is handled like normal refined oil. No stabilizers are added and no special handling precautions are necessary.

While the preferred catalyst was a sulfonic acid, for more difficult esterification, such as with trimethylol ethane where a temperature above 390° F. is used, the best catalyst is zinc (dust).

Some properties of a few typical esters are given in Table 6[5].

Other Synthetic Lubricating Oils

Other syntheses developed by the Germans included:

Tetrahydrofuran, produced from 1, 4 butanediol (an intermediate in an I.G. process for butadiene manufacture), was polymerized to motor oils. In addition it was copolymerized with smaller amounts of ethylene oxide to produce an engine lubricant and a steam cylinder oil[6]. The physical properties of the tetrahydrofuran-ethylene oxide copolymer were: pour point—0° F., VI—150, and viscosity—130 S.S.U. at 210° F.

The Deutsche Fettsaure Werke developed a water-soluble torpedo lubricant which permitted operation of a torpedo without leaving a tell-tale oil smear on the water surface. The compound was a salt of triethanol amine and an approximately C_8 fatty acid. Although not stable by the standards for lubricating oils, these salts were perfectly adequate for short duration use. Viscosity can be varied by using fatty acids of different molecular weight.

Additives

The use of additives and inhibitors was less extensive in Germany than in America. Mineral oils were used uninhibited, and no inhibitors or additives were used in the synthetic aircraft oils containing esters, or in diesel oils.

An oxidation inhibitor, a tin compound, was made by the synthesis shown in Fig. 1. Developed by I.G. and tested for improving the stability of polyethylene-mineral oil mixtures, it was not used in commercial practice.

A corrosion inhibitor was made by I.G. for special machine oils, torpedo oils and weapon oils. Prepared from a normal C_{12} to C_{18} paraffin, a fraction of Fischer-Tropsch liquid, its synthesis is shown in Fig. 2. The reaction of the paraffin with SO_2 and Cl_2 is catalyzed with ultraviolet light. The NH_3 and the chloracetic acid reactions use no catalyst. As an emulsifying soap in cutting oils, usage was 4 to

(4) Following documents relate to this process:
"Beschreibung der Schmierolanlage Rheinpreussen" (Lurgi Gesellschaft, May 31, 1945)
"Fliesbild der Schmierolsynthese Rheinpreussen".

(5) "Die Wissenschaftliche Grundlangen der Schmierstoff Synthesen" (I.G.-Leuna-Dr. H. Zorn report, May 14, 1943)
"Ester als Schmierole" (I.G.-Leuna-Dr. Zorn report, Nov. 11, 1943)
"Esterole" (I.G.-Leuna-Paper on properties and applications)
"Ester als Schmierole" (I.G.-Leuna Dr. Zorn paper listing properties of esters)
"Fliess Schema fuer Esterolenlagen Me 106 (I.G.-Leuna-Flow diagram and material balances for manufacture of several esters)
E Ol Anlage Schema I Teil and II Teil (I.G.-Leuna-Two process flow diagram for ester oil manufacture)

(6) U. S. Naval Technical Mission in Europe Letter Report No. 123-45 (S), June 12, 1945.

TABLE 6—Properties of Some Synthetic Lubricating Oil Esters

Acid	Adipic	Beta Methyl Adipic	Sebacic	Mixed C_7 Acids-Monocarboxylic
Alcohol	Iso and N-Octyl *	Normal Octyl	Isooctyl	Trimethylol Ethane
Density 68° F.	0.922	0.920	0.912	0.958
SSU at 122° F.	45.5	48	54	62
SSU at 100° F.	50	55	65	81
Viscosity Index	191	228	189	157
Pour Point ° F.	—11	—33	below —98	—94
Flash Point ° F.	405	440	455	485

* Half ester of each alcohol

6% weight; for other applications it was about 3% weight. Iron corrosion rate was reduced to 2% of that of uninhibited oil. Zinc, aluminum, and lead also showed decreased corrosion rates.

An extreme pressure additive developed by I.G., known as Mesulphol, was synthesized as shown in Fig. 3. I.G. manufactured an ingredient for aircraft break-in oils which was a phosphorus compound prepared from chlorhenzone phosphorus trichloride and stearyl amine. The use of 0.5 to 1.0% weight in oil reduced the break-in time from 50 to 10 hours. The synthesis is shown in Fig. 4[7].

Paraflow was manufactured (about 10,000 bbls. of an 8% concentrate in 1942). The process consisted of condensing 80 parts of chlorinated paraffin with 15 parts of naphthalene and one part of polystyrene, using $AlCl_3$ as a catalyst and a temperature of 85° F.

Polyisobutylene was made and sold under the trade name of Oppanol. Its use was limited to the increase of VI, making low grade oils salable as motor oils.

Lubricating Greases

Very few new developments in grease manufacture were found by the Technical Missions. Soaps were made largely from synthetic fatty acids. The oil components were almost exclusively refined fractions of Pennsylvania oils.

One development found was the use of finely divided silicon dioxide to produce gels with lubricating oils.

(7) U. S. Naval Technical Mission in Europe Letter Report No. 119-45 (S), June 12, 1945.

Partial Oxidation of Ethane Used In German Ethylene Manufacture

From Appendix 1 of Report of July, 1945
U.S. Naval Technical Mission in Europe

THE partial oxidation of ethane to produce ethylene was used by I. G. at Leuna, who obtained a 70% yield based on ethane charge. Three volumes of ethane is heated to 1110% weight, one volume of oxygen is separately preheated to 750° F., and the two are combined under slight vacuum in a carefully designed burner wherein the temperature rises to 1470-1560° F. The furnace product is cooled by exchange, and the ethylene is separated and purified to 95% weight.

On a hydrogen and nitrogen free basis, the product from the reaction burner is:

Component	% volume
Ethylene	48.1
Ethane	30.5
CO	16.0
CO_2	0.6
O_2	1.6
Propylene & higher olefins	2.4
Acetylene	0.8

Based on ethane recycle to extinction, the above analysis corresponds to an ultimate ethylene yield of 79%, which is reduced, of course, by losses in the recovery and separation system.

I. G. Leuna used a Linde fractionation system for ethylene purification. Before fractionation, CO_2 was removed with an alkazid plant (regenerative alpha-amino-propionic acid), and acetylene was hydrogenated over a nickel-chrome catalyst down to a content of 0.1% volume.

The first Linde column separated overhead materials higher than C_2, a second column separated the C_2 fraction overhead, and a third column separated ethane and ethylene. Through this fractionation, CO was also separated quite completely from the ethylene.

A second method for ethylene manufacture was worked out at Leuna and a plant was being built at Heydebrek. The dehydrogenation step in this system employs straight thermal cracking at atmospheric pressure. In a two-stage counterflow of ethane and flue gas through two furnaces, the ethane temperature is raised to 1200° F. in the first coil and 1550° F. in the second. The cracked gas is quenched, acetylene is selectively hydrogenated out, and the gas passes to a selective solvent ethylene concentration system.

In the thermal cracking operation, a conversion of 30% per pass is obtained (design figure for Heydebrek). In pilot plant work, coke deposition in the 27% chrome tubes required a cleanout only once in 40 days.

With the thermal cracking method for ethane dehydrogenation, a system of selective absorption was to be used for ethylene recovery. The solvent is a copper-diethanol amine complex, prepared by saturating diethanol amine with cuprous nitrate and adding thereto 3 to 4% weight of ammonia water. This solvent is used at 80° F. and under 10 to 20 atm. pressure. Ethylene is released by reducing pressure and increasing temperature to 105° F.

When recovering ethylene from a 30% concentration gas mixture, one volume of solvent at 15 atm. is adequate to scrub 30 volumes of gas down to an ethylene content of 0.2% volume.

This solvent will separate ethylene from paraffins but is not selective between ethylene and propylene. It will not separate CO from ethylene, and hence is not used when ethylene is produced by partial combustion of ethane. Sulfur compounds in a gas being treated with this solvent react with the solution and precipitate copper sulfide which then must be filtered out periodically. If CO is to be separated, Linde fractionation is considered the most practical method. Removal of CO with a KNi CN_3 solution has been studied, but the process is not regenerative and hence is costly for high CO concentrations.

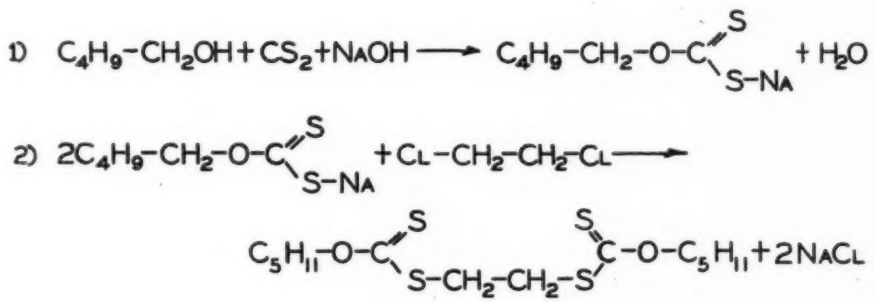


Fig. 3—An extreme pressure additive

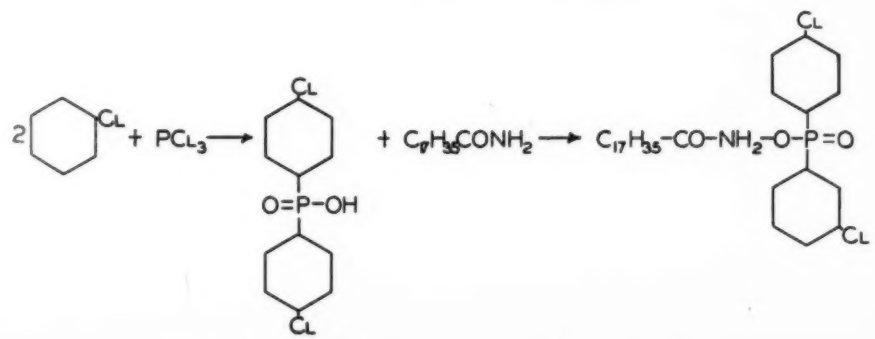


Fig. 4—A phosphorus type extreme pressure additive

Classroom Plus On-the-Job Training Pays Its Way In Instrument Course

Even Though the Course at Baton Rogue Refinery Takes 46 Months to Complete, Its Practical Value In Part Is Realized Through Improved Workmanship of the Men While Learning: Specialized Training Program Was Started to Relieve the Shortage of Skilled Help for Instrument Work which Arose During the War

By D. P. THORNTON

Assistant Editor,

Petroleum Processing

SIXTEEN years ago, at the Baton Rouge refinery of Standard Oil Co. of New Jersey (Louisiana Division), the installation, maintenance and repair of instruments was the joint repsonsibility of several refinery departments. Today its Instrument Department has 166 highly specialized workers who have either grown up with the instrument shop or who have received their training through classroom instruction alternated with on-the-job learning.

Before 1930 the Baton Rouge refinery had no particular need for an instrument department. In those days refineries did not use many instruments. A sprinkling of flow meters and temperature and pressure gages were all that could be found. The flow meters were the responsibility of the steam, water and gas department. Pressure gages, valves and flow-controllers were sent to the machine shop for repair, and the electrical department cared for electrical instruments.

By 1931 newer processes and techniques, progenitors of today's complicated refining methods, required the use of many diversified types of complex instruments. It soon became evident that a unified group was necessary to handle the growing load of instrument work. Thus the new department was born, its creation requiring more men with specialized training than were available by transferring those with instrument experience from other departments. This meant the refinery had to create its own specialists in this line.

The Instrument Department at Baton Rouge today has the responsibility of maintaining, installing and repairing approximately 20,000 instruments in the 135,000 b/d refinery which contains research laboratories, chemical plants and synthetic rubber units in addition to the conventional refinery processes. On the accurate functioning of these instruments, which range in complexity from simple pressure or temperature gages to intricate spectrometers, depends not only the efficiency of a given unit and the precision with which its products are measured for sale, but in many cases the safety of plant operators. Some part of the plant would be shut down one day out of every two if each ailing instrument were sent to the manufacturer for adjustment or repair. Hence the cost of the Instrument Department in terms of payroll, parts, inventory, equipment, and personnel schooling is money well spent, the refinery has found.

Formal Training Program

Until Pearl Harbor there was no formal schooling for instrument department apprentices. At that time the only requirement was a high school education. However, in common with many other industrial organizations, men were recruited in the '30's who had degrees in electrical, mechanical and petroleum engineering, and who were therefore already equipped with the necessary theoretical background for fluid flow mensuration and determination of pressure and temperature, as well as adequate grounding in mathematics.

These new men started as helpers or apprentices to the experienced mechanics. They alternated from job to job, to acquire practical experience. From time to time, as new types of instruments were installed in the refinery, manufacturers' representatives were called in to conduct informal "schools of instruction," in which the details of construction of the various instruments were discussed and the manner of repairs and adjustments explained.

When the rapid plant expansion coincident with World War II began, the Instrument Department lost many of its trained men to other departments of the refinery. Most were transferred as maintenance engineers to various operating units. Their instrument training and engineering education served them in good stead because they had already learned much about the operation of the equipment on which the instruments they had maintained were installed.

The department also started taking men with high school education or better who were exempt from military service because of age or physical condition. An on-the-job training program was worked out with the help of a Baton Rouge trade school and the Louisiana Department of Education. Men were paid apprentice wages while going to class eight hours daily for 12 weeks. Instructors were engineers, instrument mechanics, and foremen from the refinery. This sufficed to supply needed manpower during the war, but it was felt the program could stand improvement when times became normal again.

At present, the 46-month training program includes an unspecified number of hours of on-the-job training, plus 144 hours per year in off-the-job classroom instruction. Classes are held at the trade school, using a course worked out jointly by Standard's training department and the school. Instructors are college-trained Standard employes, paid by the school.

Applicants for transfer to the instrument department are selected from the refinery ranks, must have a high school education or better. Periodically the training department holds general examinations for interested refinery personnel, which are open to all departments. The instrument department is particularly interested in those who make high grades on the "Otis Intelligence Quotient" test and the standard Army tests for arithmetic and mechanical aptitude.

When accepted, the man enters the instrument department as an apprentice, which classification he retains during the 46-month instruction period. On satisfactory completion of the course, promotion to "instrument man second class" follows. Under the prewar plan, an apprentice depended for instruction entirely upon the mechanics with whom he

was associated and no formal classroom instruction was utilized.

In brief, the off-the-job classroom instruction includes mathematics (through elementary trigonometry), mechanical drawing, blue-print reading, physics and elementary electricity. The balance of the course consists of general technical information on instruments and instrumentation, embracing theory of fluid flow and mensuration, liquid level determination, measurement of pressure, and pyrometry.

On-the-job training pertains strictly to practical repair and maintenance of instruments. The types considered are shown in Table 1. Students work with each of the several commercial makes. Each apprentice is given a notebook containing an "Apprentice Monthly Work Record." Each day he is required to post his time on this form, bring it to the foreman in charge of apprentices for initialing and rating. At the end of the month the ratings are applied and the form sent to the training department for posting on the employe's permanent record.

The trainees are graded primarily on their attitude toward the work—how fast they "catch on" to explanations and pay attention to instruction. Ratings are also applied for workmanship and speed. Five grades are given: "E" for excellent, "G" for good, "F" for fair, "P" for Poor and "D" for "dead job."

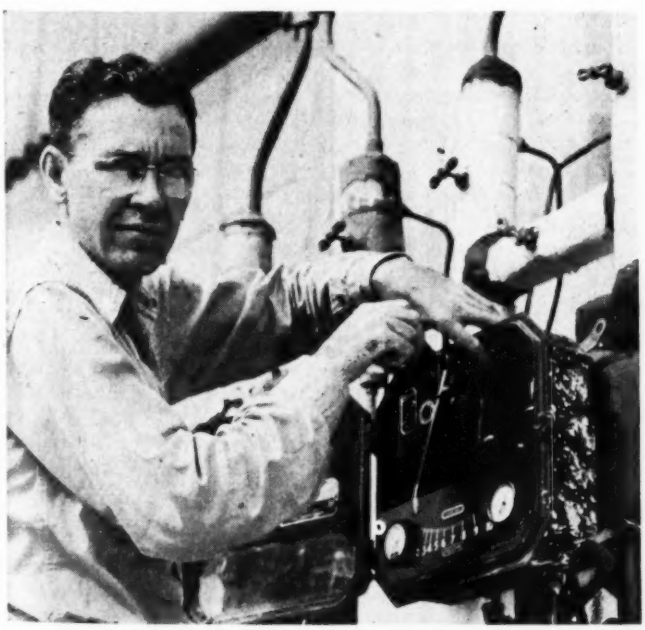
The first thing on-the-job apprentices are taught is to give a specific type of instrument the maintenance normally required. Next come the tests usually given to "prove" the instrument in proper working order, and how to remove and replace those parts which most commonly require this attention.

Later they are taught the specialized "trouble shooting" techniques used to decide whether or not an instrument has "gone wrong" in the field and if it must be brought in to the shop for repairs. Oftentimes this decision requires knowledge not only of the mechanics of the instrument but its specific application on a unit. Is it the control instrument itself, or the valve which it may operate, that is faulty, or is it the instrumentation or something else about the unit which is causing the difficulty—these are common problems the instrument man must solve.

As an illustration, some time ago a flow meter on a large high-pressure steam line began giving erratic results.

TABLE 1—Instruments Studied in Apprentice Training at the Baton Rouge Refinery

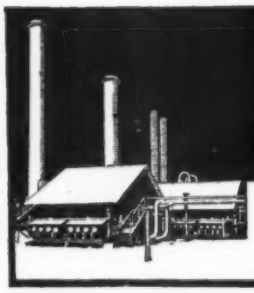
A. Flow Meters (Differential Pressure)
  1. Aneroid
  2. U-tube manometers
  3. Mercury type (mechanical)
  4. Mercury type (electrical)
B. Flow Meters (Volumetric)
  1. Rotary
  2. Piston
  3. Nutating disc
  4. Oscillating piston
  5. Wet test
  6. Dry gas bellows
  7. Velocity
C. Rotameters
  1. Flow
  2. Viscosity
D. Pressure Instruments
  1. Indicators
    a. Draft gauges
    b. Bourdon-tube
    c. Bourdon-tube (diaphragm)
    d. Bourdon-tube (helical and spiral)
    e. Hydron or bellows
  2. Recorders
    a. Spiral spring
    b. Helical spring
    c. Bourdon-tube
    d. Hydron or bellows
E. Liquid Level Instruments
  1. Mercury differential
  2. Ball float—internal and external
  3. Displacer
  4. Aneroid (differential)
  5. Expansion tube
  6. Kidney float
  7. Mercury differential
F. Temperature Instruments
  1. Thermal tube
  2. Thermocouple (mechanical)
    a. Potentiometer (galvanometer)
    b. Pyrometer
  3. Thermocouple (electronic potentiometer)
G. Control Valves & Regulators
  1. Diaphragm control valves
  2. Piston-actuated regulating valves
H. Control Systems Pneumatically Actuated
  1. Throttling controllers
  2. Throttling controllers with automatic reset
  3. Boiler control systems
  4. On-off controllers
I. Control Systems Hydraulically Actuated
J. Control Systems, Electrically or Electronically Actuated
K. Transmission Systems (Telemetering)
  1. Hydraulically actuated
  2. Electrically or electronically actuated
  3. Pneumatically actuated
L. Signal Lights, Alarms and Safety Cut-offs
M. Specialized Instruments
  1. Calorimeters
  2. pH meters (indicating and recording)
  3. Refractometers
  4. Combustible gas alarms
  5. Ultraviolet spectrophotometers
  6. Infrared spectrophotometers
  7. Thermal conductivity instruments
  8. Specific gravity recorders
  9. Boiler water treating and control instruments
  10. Timers and blow-downs
  11. Automatic timers
  12. Orifice fittings
  13. Strip heater controllers
  14. Podbielniak analysers (fractional distillation)
  15. Psychrometers
  16. Carbon dioxide recorders



Instrument mechanic in the field sets the zero adjustment on an aneroid-type differential flow transmitter. Some instruments are zeroed daily at Jersey Standard's Baton Rouge refinery

An embryo instrument mechanic in the field adjusts the zero point of a mercury-type differential flow recorder under the expert tutelage of his mechanic-instructor

TODAY outmoded heating equipment is as unnecessary and just as detrimental to efficient results as the flickering oil lamp at the operating table. As pioneers in the design and construction of heaters for processing oil products, Alcorn is well qualified to help you solve your heating problems. Whether you need new installation or modernization of existing equipment, let Alcorn provide the answer in terms of higher production and lower operating costs.



ALCORN
Combustion Company
SCHAFF BUILDING, PHILADELPHIA
Los Angeles • Houston • San Francisco • Tulsa

The instrument was checked and found in good order but continued to give unreasonable figures. It was finally removed for shop examination but the tests there did not show it to be out of order. As a last resort the line was broken to inspect the orifice plate. This was found badly encrusted with scale and plugged almost completely. A new plate was installed, the old meter returned, and the mystery marked "solved".

Another time a potentiometer recorder-controller suddenly began giving "goofy" answers without apparent reason. Repeated checks failed to show why, at erratic intervals, it should suddenly go up- or down-scale for a brief interval. Finally the "ghost" was laid and it was found that a cockroach would occasionally get on the delicate galvanometer needle, displacing it from its proper position and thus causing the pen-carriage and controlling mechanism to move to an abnormal position. Since this happened before the day of DDT, such instruments were immediately placed in insect-proof housings.

Most Work Is in the Field

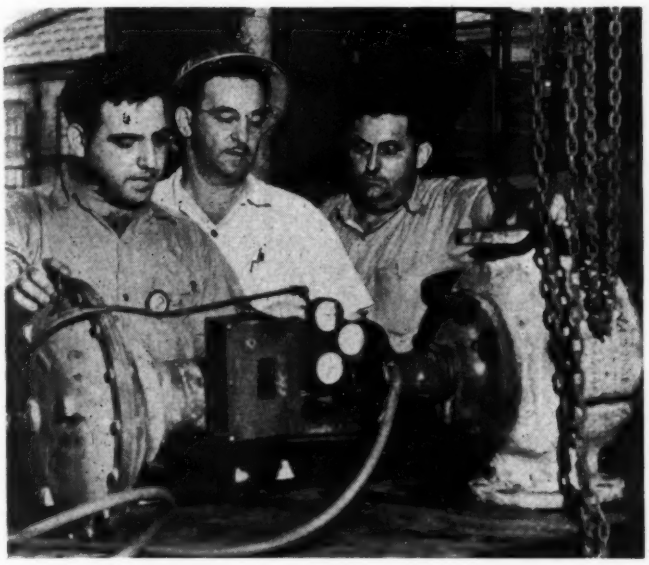
Organization and administration of the instrument department is not complex. The men are divided into five crews; three in the field, one in the shop and a swing shift. They operate 'round the clock on the usual 8-hour day. Men are classified as timekeepers and clerical help, combination instrument mechanics, instrument men first, second and third-class, and apprentices.

Individuals are assigned to regular operating divisions within the refinery. Assignments are rotated from time to time, so that all become familiar with plant-wide operations and can be switched from point to point as necessary. On a turn-around a number of instrument men are concentrated temporarily at the one unit.

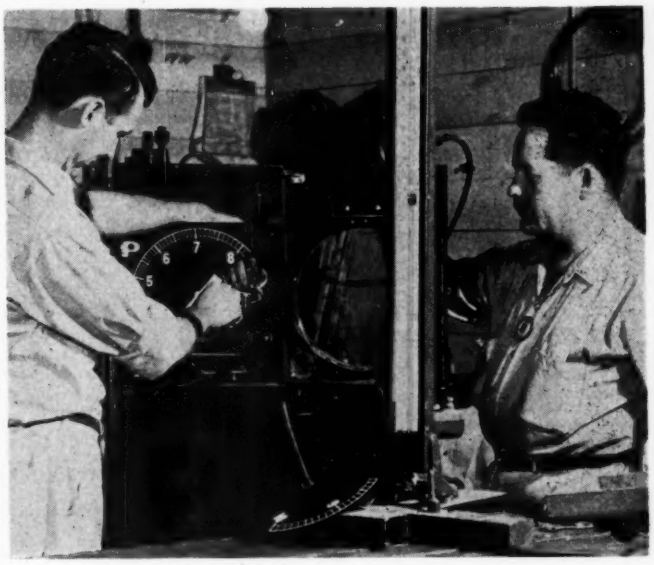
The instrument men report to the shop and pick up their kits each day, heading to the field for a regular routine of examination, maintenance and minor repair work which touches every instrument on each operating unit in the refinery. Only when assigned to the "Chemical Products area", geographically some distance from the main refinery units, do instrument men work from "Mechanical Zone Shops". These serve as a place for keeping tools and a shelter where mechanics in all crafts can work in bad weather. A small amount of specialized equipment is also located there to prevent swamping the main shop with minor repair jobs.

Most instrument work is done by the field men; there are only 13 mechanics on duty in the shop per shift. If the required job can be completed without dismounting the instrument it is handled on the spot. If not, it is tagged to show reason for removal, location and service, then sent to the shop for repair; if contaminated it must be rendered safe to handle before sending in.

All refinery instruments are classified



Under the watchful eye of their instructor, two instrument shop apprentices test a pneumatically-operated diaphragm control valve for proper plug travel after its repair. Standard's Baton Rouge refinery has over 2500 such valves operated by control instruments.



The apprentice (left) is learning how to calibrate a mercury-type differential flow indicating transmitter. Tall instrument in center is manometer, used during calibration to determine pressures for setting the transmitter.

for regular attention on a basis of prior experience or for other special reasons. Some are examined daily, others weekly, bi-monthly and monthly. All instruments are carefully checked during routine maintenance on the unit of which they form a part. For example, thermocouples are always renewed every time a unit comes down for general inspection, although these items are usually not replaced on "normal turn-around" unless they have been giving trouble.

A few highly specialized instruments are checked daily. Certain meters, for instance, are zeroed daily and calibrated regularly for accounting purposes. Others, such as calorimeters, ultra-violet and infra-red spectrometers and refractometers, are also examined daily. Potentiometers in general receive weekly routine inspections, at which time they are lubricated and standardized.

"Shopping" Instruments

The instrument shop does not bar any kind of an instrument job, although the work is usually confined to repair of damaged and worn-out devices. Routine maintenance and adjustment jobs are handled only during turn-around time at the units, and are confined to the excess over what the field crew can handle in the time allotted. Range changes to permit the instrument to handle a different application than its former service are common.

Occasionally an almost complete rebuilding job occurs. Designing and building new instruments from the ground up is kept to a minimum. In most cases it is deemed less expensive in the long run to buy a commercial instrument for the particular application rather than invent one.

The shop keeps very few spare instruments. Of these, pressure gages and displacement and differential flow meters are the most common. One or two indicating pyrometers and a recording potentiometer are generally available as spares. A good stock of parts is regarded as much more important than spare instruments, since it is usually the work of but a few minutes to replace the faulty portion of a mechanism with a new part. It is argued that in a case where an on-the-spot replacement of an inoperative part is not possible, the failure will usually bring the unit down anyway. Intelligent maintenance minimizes such occurrences.

For efficiency, instrument shop personnel are specialized. A six-man gage division maintains pressure gages, mechanical and thermal tube pyrometers, and positive displacement flow meters handling liquids or gases. The pyrometer section of two men repairs both electronic and electrical types of instruments. The flow control and valve crew, four men, concentrates on automatic and differential flow meters, control valves and liquid level controllers. One man is responsible for clock maintenance.

In 1945 the instrument department maintained the major items shown in Table 2, along with a host of "miscellaneous" and specialized varieties which are not mentioned. The list included more than the 20,000 instruments total for the whole refinery, which indicates the department personnel let no grass grow under their feet despite their small number when compared with total refinery payroll.

No heavy mechanical work is done by the instrument department, hence its equipment does not include specialized jigs, lathes, shapers, and other types of machine shop equipment. Where instruments require work involving other mechanical crafts, such as welding and machining control valves, they are dismantled in the shop and sent to the appropriate section of the mechanical department. The instrument shop is not equipped with "unusual" instruments or gadgets. But all the facilities necessary for maintaining and repairing refinery instruments are there with that well-taken-care-of look which bespeaks good equipment properly used.

TABLE 2 —Partial List of Instruments Shop Repaired in 1945 at Baton Rogue Refinery

6000	Pressure gauges
5500	Thermometers
2500	Motor-operated valves
1700	Flow recorders and indicators
900	Flow controllers
375	Temperature controllers
700	Temperature indicators and recorders
750	Liquid level controllers, indicators and alarms

Recent Articles on Instrumentation

"How to Organize Instrument Maintenance and Repair Department," National Petroleum News, *Technical Section*, Feb. 6, 1946; pg. R-113.

"One Boss for the Instruments," National Petroleum News, *Technical Section*, May 1, 1946; pg. R-329.

"Instrumenting the Fractionator for a Catalytic Cracking Unit," PETROLEUM PROCESSING, Sept., 1946; pg. 52.

91—Octane Gasoline Can Be Made By Naphtha Isomerization Process

The isomate process for naphtha isomerization of Standard Oil Co. (Ind.) was operated for 0.7 to 1.0 cent gal. reactor charge in a 5000 b/d plant at Whiting, and a 1750 b/d unit at Salt Lake City. High quality fuels can be produced from any pentane-hexane feed stock, even normal pentane and normal hexane.

Operating problems caused by the highly corrosive catalyst, an aluminum chloride-hydrocarbon complex, were solved by the use of Lumnite-reinforced lining on nickel-clad walls of reactors, and Hastelloy as material for most valves, fittings, and lines. Carbon steel was found satisfactory in some portions of the equipment.

MOTOR gasoline of 91 octane number (CFR-M) with approximately 100% liquid yield can be produced by the Isomate process for naphtha isomerization, according to a recent report by engineers with the Standard Oil Co. (Ind.), and the Utah Oil Refining Co.

In one pass operation, Isomate of about 80 CFR-M unleaded octane number can be produced, and by separation and recycling of low octane number pentanes and hexanes, approximately 91 unleaded octane number fuel can be produced. Two plants have been constructed and successfully operated: a 5000 b/d plant at the Whiting refinery of Standard (Ind.), and a 1750 b/d unit at the Salt Lake City refinery of Utah Oil Refining Co., a Standard (Ind.) subsidiary.

The catalyst employed is a liquid aluminum chloride hydrocarbon complex promoted with anhydrous HCl; hydrogen is added to repress cracking and maintain high catalyst activity. The liquid naphtha charge is passed in a dispersed phase through the catalyst complex. Reaction conditions are 240-250° F. and 700-800 psi.

The material presented in this article is a condensation of a paper, "The Isomate Process," by J. E. Swearingen, and R. D. Geckler, Standard Oil Co. (Ind.), and C. W. Nysewander, Utah Oil Refining Co., presented at the Houston meeting of the American Institute of Chemical Engineers, March 31, 1946, and published in the Institute's *Transactions*, Vol. 42, August, 1946.

Under present conditions, Standard's engineers believe the Isomate process will be in great demand. They point out that today the oil industry faces a revolution in refining operations. War born facilities have pushed octane ratings of motor gasoline to levels not even anticipated before the war, with the end not yet in sight. The tremendous drains upon the nation's crude oil resources during the war years and the growing difficulty of finding new reserves will have the certain effect of substantial rises in crude oil prices.

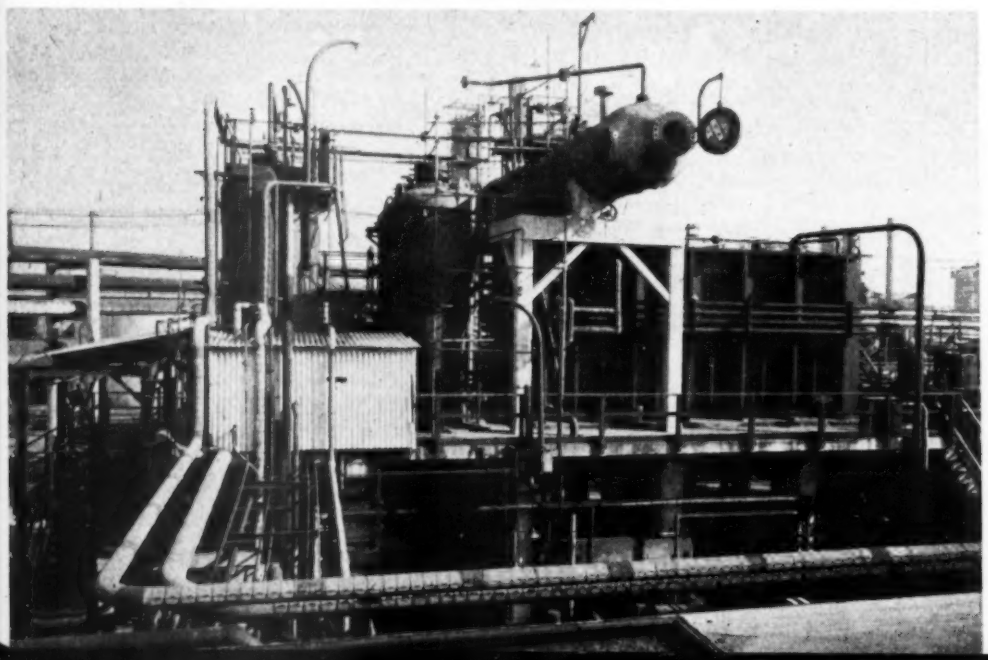
Operates For Less Than Cent a Gallon

An Isomate unit can be operated for 0.7 to 1.0c/gal. of reactor charge, it has been found, depending upon refinery feed stock, fuel prices, and costs for $AlCl_3$, HCl and hydrogen. This is competitive with the cost of using tetraethyl lead for raising octane number at current levels only for low quality feed stocks consisting largely of normal paraffins. For mixed pentane-hexane feed stocks, the Isomate process is not competitive with tetraethyl lead at current octane levels, but it is comparable to other methods of raising quality above ceilings possible with conventional refining procedures.

Standard's engineers believe it is likely that at least one third of the gasoline marketed in the U. S. will continue to be low octane number straight run. They feel, therefore, that the Isomate process, which raises the octane number of such material by improving the quality of the pentane-hexane fraction, should find definite application.

Typical feed and products from mid-continent type naphtha are shown in Table 1. "Neohexane" shown in the table is a superfractionated cut from the Salt Lake City operations and indicates the high quality product which can be made. Due to the nature of the process, products of the quality shown can be produced from any pentane-hexane feed stock—even normal pentane and hexane.

Reaction system of the Whiting Isomate unit. Feed driers are at lower left, reactors in center, hot settler in upper center (open) and reactor aftercooler on right



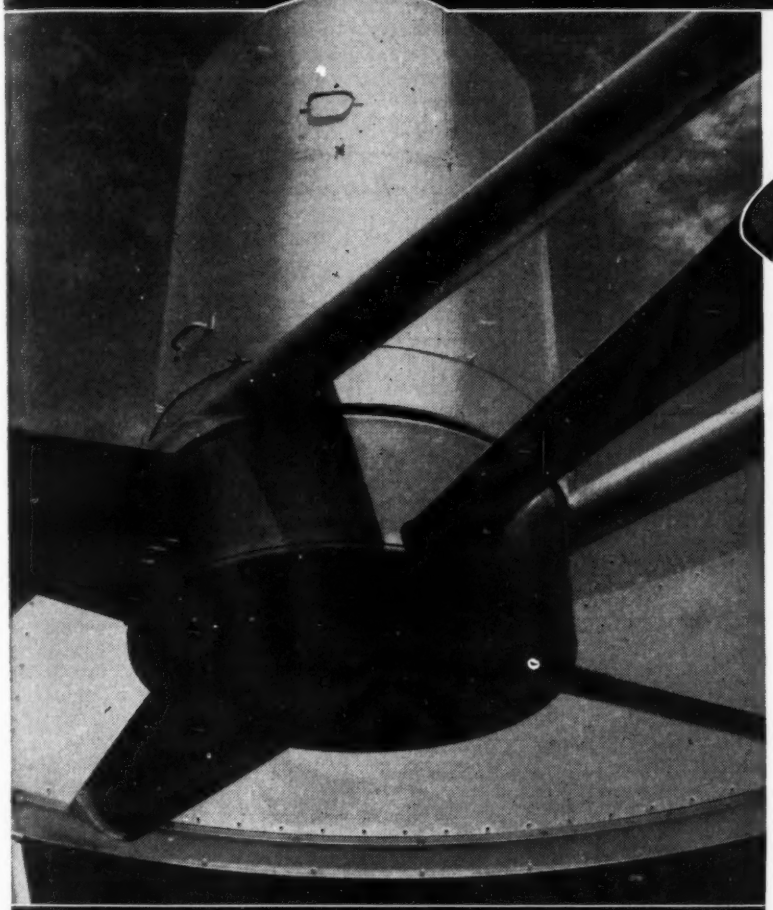
Corrosion Cuts Operating Efficiency

The onstream efficiency of both the Whiting and the Salt Lake City installations has been impaired by corrosion difficulties requiring numerous and sometimes lengthy shutdowns. These shutdowns were in large part the result of the substitute materials used because of wartime shortages, and in part to problems not revealed in pilot plant studies.

It was therefore not entirely unexpected when the Whiting plant, the first put on stream, averaged only 67% operating efficiency for 17 months' operation. The Salt Lake City unit, taking advantage of the Whiting experience, achieved 82% efficiency during 15 months' operation. With present knowledge and skills, an operating factor in excess of 90% is expected for the future.

The principal difficulties arose from the

The *EXTRA VALUES* You Receive from Pritchard Cooling Towers



Patented Pritchard SEALDFLOW fan drive over FEATHERWEIGHT (Monel metal) induced draft fan

result from *features like these*

FANS extremely light in weight, requiring less power. True airfoil blades of corrosion-resisting wrought Monel welded to a rugged internal frame, with pitch adjustable to permit optimum setting for any tower loading. Other advantages worthy of examination.

DRIVES composed of integral vertical gearhead motors, eliminating right angle gears, flexible couplings and alignment problems. Write for complete information.

DISTRIBUTING SYSTEM that is the most lastingly trouble-free yet devised. All-redwood, capable of 100% overload with completely uniform water distribution. Get the full facts on its unique design.

AIR-INTAKE SYSTEM that applies sound and progressive engineering to air inlets, to the benefit of air distribution and the virtual elimination of winter troubles. 5 different arrangements available at same price. Let us give you the details.

STRUCTURAL STRENGTH that is second to none, employing more redwood and LESS corrodable iron and steel; skillful use of ample diagonals, ring connectors, angle washers, etc. The "fine points" of Pritchard construction merit your closer study.

DECKING-that achieves ideal water break-up over its entire cubic area and remains permanently level.

DELIVERY DATES that carry the assurance, based on a consistent history, of completion promises and performance guarantees being met or bettered.

On all these points, and for towers of all sizes and types, Pritchard has an outstanding record to show you, worthy of your inquiry. Write or call the office near you.

EQUIPMENT DIVISION, Fidelity Bldg., Kansas City 6, Mo.

Pritchard EQUIPMENT

THE LINK TO BETTER PERFORMANCE

- "Airdfin" Air-Cooled Heat Exchangers
- Cooling Towers, All Types and Capacities
- Shell & Tube and Atmospheric Heat Exchangers
- "Hydryer" Air and Gas Drying Units
- "3-Zone" Cleaners and Separators for Air, Gas and Steam
- Air Treaters for Purification and Positive Control of Moisture and Temperature in Air Conditioning Systems

For more information, see Sweets Files, Chemical Engineering Catalog, Refinery Catalog, ASH&VE Guide or ASRE Data Book

NEW YORK, CHICAGO, LOS ANGELES, DETROIT, PITTSBURGH, ST. LOUIS, HOUSTON, TULSA, ST. PAUL, OMAHA, DENVER, ATLANTA, SALT LAKE CITY, EL PASO, MEXICO CITY

J.F. Pritchard & Co.

ENGINEERS • CONSTRUCTORS • MANUFACTURERS

for the CHEMICAL, PETROLEUM, GAS & POWER industries

TABLE 1—Typical Isomate Feed and Products

	35% Pentanes 65% Mixed Hexanes		Mixed Hexanes		
	Feed	Isomate	Feed	Isomate	"Neohexane"
Gravity, ° API	77.8	80.8	71.3	71.2	86.3
Reid Vapor Pressure, psi.	10.0	10.0	4.9	7.1	11.0
ASTM Distillation, ° F.					
Initial	106	108	145	115	110
10%	117	113	149	130	112
50%	130	127	152	149	118
90%	149	160	157	185	126
Maximum	155	278	180	349	135
Octane Ratings					
CFR-M, Clear	70.1	79.8	69.5	79.4	87.7
1.0 cc./gal. TEL.	80.0	89.7	80.3	89.4	100+0.04
3.0 cc./gal. TEL.	87.2	95.9	86.5	93.6	100+0.67
AFD-1C, Clear	68.7	77.1	66.8	77.4	88.7
4.0 cc./gal TEL.	90.6	100+0.06	90.6	97.2	100+1.40
AFD-3C, 4.0 cc./gal. TEL.	92% S	99% S	...	S+0.5	S+1.55

highly corrosive nature of the $AlCl_3$-hydrocarbon complex. The most important factors tending to increase corrosion are believed to be (1) turbulence, (2) high HCl concentration, and (3) active catalyst (one containing much free $AlCl_3$). Welding strains and high temperature also increase corrosion, and galvanic action occurring where nickel or carbon steel is welded to Hastelloy is also apparently a contributing factor.

Considerable plant experience showed that Hastelloy B is the only metallic material which successfully withstands the action of the catalyst complex. Unfortunately, at the time the two units were designed, Hastelloy fabrication facilities were unavailable because of the war, and the reactor walls were coated with nickel as a substitute. As an added protection for the nickel clad vessels, a liner of Fibreglas-reinforced cement was applied. These liners were used for several months, but were not entirely satisfactory. Curing of the liners apparently loosened the bond between the cement and the wall, and after several months the liners invariably bulged and sagged permitting the complex to attack the metal.

Following the indifferent success of the Alkor-glass cloth liners, a 2" layer of Lumnite cement reinforced with 3/8-in. steel bars and 2 in. x 2 in. 18 gage wire was installed in each reactor. As a further precaution, outside insulation was stripped from the reactors, and the metal walls were cooled by a spray of water since available data indicated that the corrosion rate decreased about tenfold for 100° F. lowering in temperature. It was predicted that the combination of the water spray and the 2-in. cement liner would maintain the wall temperature close to that of the cooling water. Actual tests have since borne out that the wall temperature is about 30° F. higher than the water.

This method of corrosion protection was used at Whiting from July, 1944, until the unit was shut down in August, 1945. Liners were removed on three occasions, after 1800, 1700, and 4100 hours' service. In all cases the cement displayed a pattern of fine cracks with some complex penetration to the wall, but general corrosion was negligible.

Hastelloy Used

Transfer lines between the reactor and the stripper should be lined with Hastelloy B, and Hastelloy B valves should be used. All nozzles on the reactors should be similarly protected. Double extra heavy 4-in. carbon steel pipes (4½ in. O.D., approximately 0.674 in. wall thickness) are used in the reactor after-cooler and must be replaced periodically. Corrosion rates as high as 0.72 in./year in the first few tubes of the cooler have been observed. Hastelloy tubes would eliminate corrosion at this point but are probably not justified on account of their high initial cost.

Carbon steel is satisfactory for both the hot and cold settler because of the low turbulence, but all valves, fittings, and connections should be made of or lined with Hastelloy B. Inasmuch as either HCl or $AlCl_3$ alone dissolved in naphtha is not particularly corrosive, the reactor charge line and $AlCl_3$ slurry line can be made of carbon steel. Carbon steel construction for the HCl stripper and absorber has given excellent service with negligible corrosion at both Whiting and Salt Lake City.

Three separate steps are involved in the operation of an Isomate unit: (1) feed preparation, (2) isomerization, and (3) product fractionation. The feed should be relatively free of C_4 and C_7 hydrocarbons; normal butane will not isomerize to any appreciable extent under Isomate process conditions, and heptanes crack with decidedly detrimental effects on catalyst activity and life. The extent of feed preparation facilities depends largely on the regular practices in each specific refinery. For instance, if straight run naphtha is superfractionated to segregate isopentane and high quality hexane and heptane fractions, by-product normal pentanes and hexanes would be satisfactory charging stock. In other cases, a reasonably sharp cut naphtha fraction will be suitable.

Isomerization Step

Fig. 1 shows a simplified flow diagram for the isomerization step. Dry fresh feed—pentanes, hexanes, or a mixture of the two—is fed to the top of a conventional absorber where it contacts HCl and gas recycled from the cold settler and the HCl stripper. Naphtha and HCl are drawn from the bottom of the absorber, and gas consisting principally of hydrogen and methane is released overhead. The liquid from the absorber is pumped through a preheater, and after addition of hydrogen is charged to the reactor, an unpacked vessel containing $AlCl_3$-hydrocarbon complex. The charge is distributed at the bottom of the reactor by a "spider" consisting of 2-in. Hastelloy pipes perforated with ¼-in. holes.

Due to the difference in density, naphtha rises from the distributor through the catalyst; isomerization occurring during this contact. Isomerized naptha, or Isomate, flows from the reactor into the hot settler, a vessel which collects entrained complex, and which is operated at the same pressure and temperature as the reactor. The small amount of complex accumulating in the hot settler is periodically drained off.

Effluent from the hot settler passes through a pressure reducing valve, a water cooler, and into the cold settler.

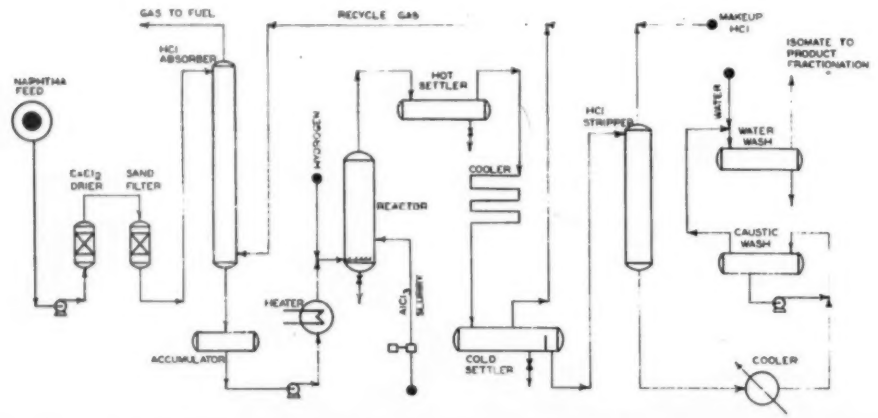


Fig. 1—Flow diagram, Isomate process for Naphtha Isomerization

This vessel is carried at a pressure slightly higher than the HCl stripper and serves both as a settler for $AlCl_3$ and as a flash drum to remove hydrogen and HCl from the reactor effluent. The product from the cold settler is charged to the top of the HCl stripper. Stripper overhead, along with flashed vapors from the cold settler, is returned to the HCl absorber. The stripper bottoms, containing less that .01% wt. HCl, is passed through a caustic and water wash system to the fractionation towers.

Stripper Steam Isolated from Reactor

Steam pressure in the HCl stripper reboiler is kept below the tower pressure as a precaution against leakage of steam into the reaction system with the resultant formation of highly corrosive muriatic acid. Condensate from the reboiler is periodically checked for acidity to detect leaks in the reboiler tubes before severe acid attack can occur.

Catalyst activity is maintained by adding anhydrous $AlCl_3$ in a naphtha slurry, and occasionally withdrawing from the reactor excess complex produced from the reaction of $AlCl_3$ with hydrocarbons.

The hydrogen required at both plants is produced from dry gas—principally methane and ethane—by the water gas reaction. Anhydrous HCl is made by dehydration of muriatic acid with black sulfuric acid of about 93% acidity.

A simple arrangement of the fractionation system is shown in Fig. 2. Washed HCl stripper bottoms are passed to a depentanizer tower where normal pentane and lighter hydrocarbons are taken overhead, and hexanes and heavier hydrocarbons are eliminated as bottoms. The depentanizer overhead passes to a debutanizer where butanes as overhead go to alkylation feed, and a mixture of iso- and normal pentane is separated as bottoms. These bottoms are split to produce isopentane for blending in aviation gasoline, and normal pentane which is recycled to the HCl absorber or sent to motor fuel.

Bottoms from the depentanizer are pumped to a hexane splitter where neohexane, di-isopropy, and small mounts of other hexanes are taken overhead to aviation gasoline blending. Hexane splitter bottoms are fed to the rerun tower where paraffinic hexanes are taken overhead for recycling to the HCl absorber, and a naphthenic bottom is produced for aviation gasoline blending.

The arrangement of fractionating equipment at Whiting and at Salt Lake

Process Described

The Isomate process of Standard Oil Co. (Ind.) has been described in an earlier article: "Commercial Isomerization of Light Paraffins," Evering, Weems, Fragen, published in the *Technical Section* of *National Petroleum News*, Nov. 1, 1944, pg. R-737.

REFINING • LUBRICANTS
PROCESS CONTROL

Add these Latest Books to
Your Library of Valuable Technical Information

American Petroleum Refining *{By H. S. Bell}*

Contains *all* the most up-to-date developments in petroleum technology . . . From the crude storage tank to the finished product, *every step* in modern refinery engineering and operation is *given in full* . . . The methods of calculation of the chemical, physical and engineering data needed in practical design are fully explained, with the information arranged in hundreds of comprehensive tables and graphs, and with sample problems to show every step in practical applications. Photographs and diagrams illustrate refinery construction. Included are flow sheets of processes and details of apparatus. Each important class of refinery equipment is the subject of an entire chapter which covers its design from the basic principles and calculations down to the details of construction . . . . . 640 pages, Illustrated and Indexed, $7.50

Lubricants and Cutting Oils for Machine Tools *{By W. G. Forbes}*

Covers the fundamentals of lubrication and the application of numerous types of cutting oils in relation to machine tool operations . . . Discusses the various properties of lubricating and machine oils, their relative importance, and methods of testing, as well as their composition, compounds and blends . . . Suggests points to be covered when specifying lubricating and cutting oils . . . Deals with lubricating greases. Gives practical applications of cutting oils . . . Prescribes treatment and offers suggestions for the prevention of skin diseases resulting from contact with lubricants . . . . . 90 pages, $1.75

Lubrication of Industrial and Marine Machinery *{By W. G. Forbes}*

Discusses principles of lubrication for common types of engines and machines; with descriptions, explanations and analyzations of everyday lubrication problems. Covers mechanics of lubrication, fundamentals of production, tests and specifications for lubricating oils, and methods of applying lubricants, 314 pages, $4.00

Instruments and Process Control *{By R. E. Clarridge, J. S. Detwiler, G. E. Heller, R. N. Pond and B. C. Delahooke}*

Written in layman's language, this monograph was prepared in the Curriculum Laboratory at Cornell University in cooperation with the Taylor Instrument Company . . . Explains industrial processes and the measurement and control of their variables . . . Defines common instrument terminology . . . Discusses basic control theory, simple controllers, controller mechanisms, and the applications of controllers . . . Contains over 200 illustrations, photos and drawings . . . Well prepared and easy to read . . . . . Reproductions of 233 typewritten pages 8½ x 11, paper cover and plastic bound, $2.75

A. S. T. M. Standards on Petroleum Products and Lubricants *{1945}*

Contains 80 standard and 5 emergency standard methods of test; 11 standard and 2 emergency specifications and 3 standard definitions. Covers gasoline, fuel oils, Stoddard solvent, cut-back and emulsified asphalt (several grades of each) mineral spirits and thermometers . . . Appendices show the results of tests on the development of a method for estimating maximum pour points of lubricating oils containing pour point depressants . . . and the proposed method of test for such pour points . . . also the proposed method of test for total olefinic and aromatic hydrocarbons in gasoline . . . 546 pages, $2.75

Mail your order for the above books to:

PETROLEUM PROCESSING
1213 WEST THIRD STREET • CLEVELAND 13, OHIO

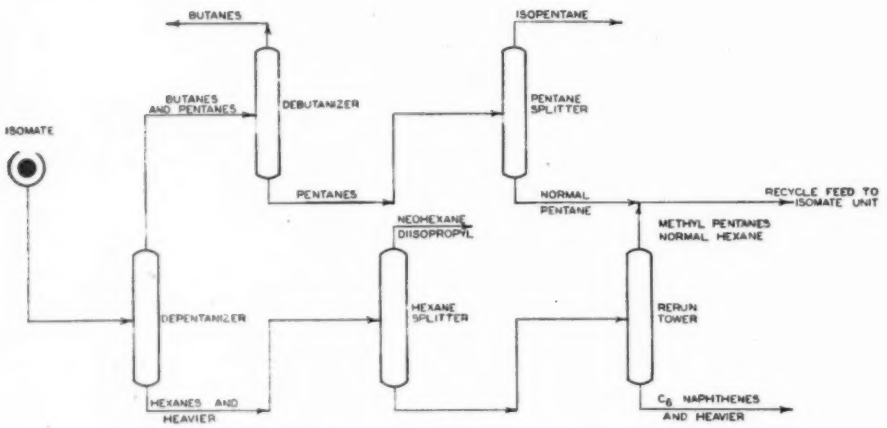


Fig. 2—Simplified flow sheet, Isomate fractionation system

City differs somewhat from the scheme shown in Fig. 2, but the flows employed were dictated by the specific equipment available and the particular aviation gasoline blending problems. Both units were originally designed for single pass operation on pentane and hexane. At Whiting with a requirement for additional isopentane, the unit was converted to pentane recycling, but at Salt Lake City with a shortage of feed stock and excess isomerization capacity, hexane recycling proved to be advantageous.

Catalyst Addition Rates

Addition rates required to maintain catalyst activity depend in large measure upon the feed stock and the product quality desired. For operations to date hydrogen addition has varied from 50 to 180 cu. ft./bbl. of reactor charge, with a minimum of 30 cu. ft./bbl.; HCl concentration has ranged from 4 to 8% wt. of reactor charge with a minimum of about 2%; $AlCl_3$ addition from 0.5 to 1.0 lb./bbl. with a minimum of about 0.3 lb./bbl. Hydrogen consumption was 25-40 cu. ft./bbl. and HCl consumption 0.2-0.3 lb./bbl.

The light naphtha charge should be substantially free of moisture and should contain not more than about 2% C_7 hydrocarbons. Carbon monoxide is a severe catalyst poison, and hydrogen employed should contain not more than about 0.2 mol-% CO.

In addition to the corrosion problems discussed previously, transfer of solid $AlCl_3$ from atmospheric pressure to the reactor pressure of 700-850 psi was a chemical engineering design problem in the first commercial installation. The injection of $AlCl_3$-naphtha slurry as finally adopted has proven quite satisfactory. A diagram of this system is shown in Fig. 3.

Granular $AlCl_3$ of 18-100 mesh falls from the storage hopper through a rotating star feeder to the slurry tank. Here it is mixed with incoming Isomate by means of a centrifugal pump circulating the tank contents from bottom to top through the slurry loop line. Slurry is injected into the reactor by a double-acting plunger type pump which takes suction on the loop line. Aluminum chloride is prevented from entering the slurry pump cylinder by using check valves in the lines and surge chambers between the valves and the pump cylinder. The surge chambers are continually flushed with a small quantity of Isomate. Linear velocities of 1 ft./sec. in vertical lines and 6 ft./sec. in horizontal lines are sufficient to maintain a slurry containing 1 to 5 lbs./gal. $AlCl_3$.

Pentane and Butane also Isomerized

Coincident with the naphtha isomerization development two other processes have been developed, one for isomerization of pentane alone, and the other for butane isomerization. A 1620 b/d pentane isomerization plant is in operation at the Texas City, Tex., refinery of the Pan American Refining Corp., and two butane isomerization units were constructed and are being operated—one of 4530 b/d at Whiting, and one of 4250 b/d at Wood River, refineries of Standard Oil Co. (Ind.). The processes used involve only slight modifications of the general principles of the Isomate process.

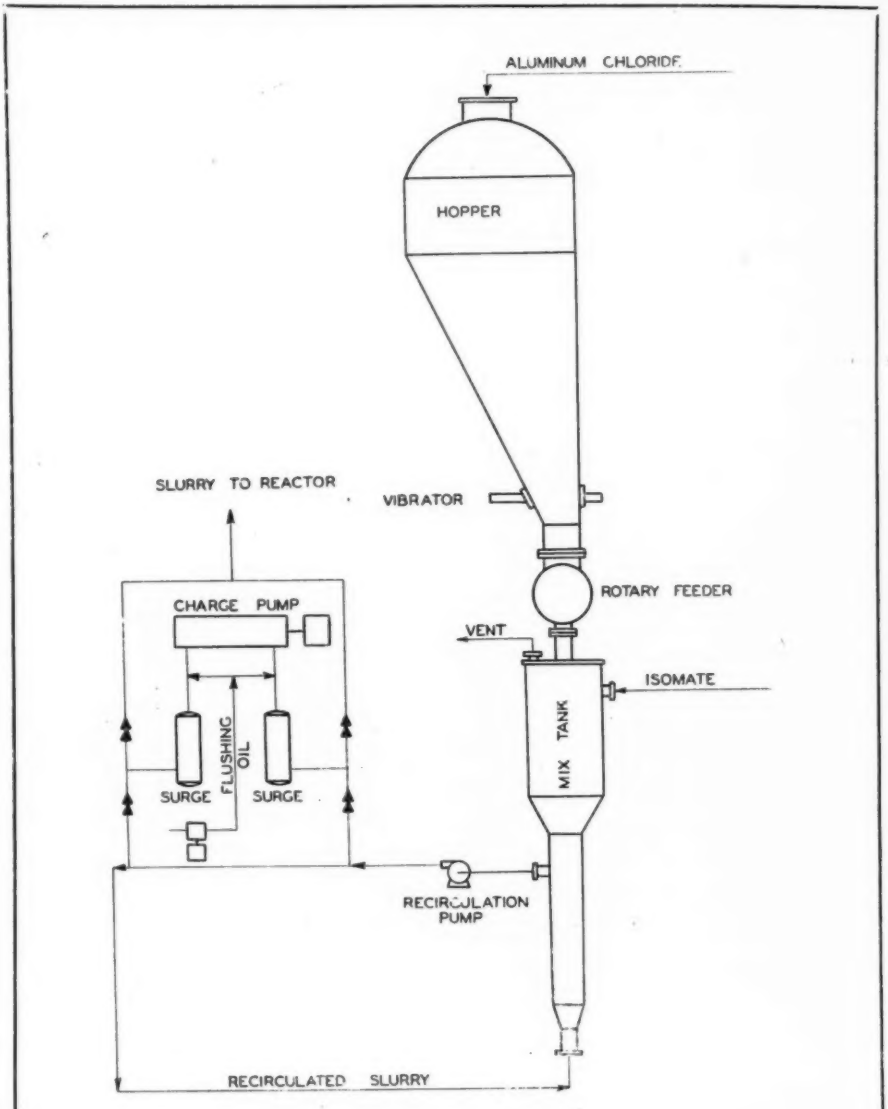


Fig. 3—Equipment for preparation of $AlCl_3$-hydrocarbon slurry

RESEARCH
is a Vital Part of
PETRECO SERVICE
EVER SINCE the development of the Petreco process, the Petreco research division has carried out a carefully planned program to improve, develop and broaden the scope of this process. From these efforts came many of the features that are money-savers for Petreco customers. When one Petreco customer encountered salt troubles in his refinery, Petreco research developed Electrical Desalting—a Petreco process which has gained international recognition and acceptance.
It should be remembered that the Petreco processes are applicable to crude and refined oils. If you have *any* problem relative to demulsification or the removal of impurities from oils, get in touch with one of the Petreco laboratories; your inquiries are cordially invited and such consultation involves no obligation.
PETROLEUM RECTIFYING COMPANY
5121 So. Wayside Drive, Houston 1, Texas
648 Edison Building, Toledo 4, Ohio
530 W. Sixth Street, Los Angeles 14, Calif.
PETRECO
DESALTING ★ ELECTRICAL PROCESS ★ DEHYDRATING

Improved Techniques for Chemical Refining of Petroleum Reported at ACS Meeting

IMPORTANT new data on the reactions occurring in some of the commercial refining processes, resulting from extensive oil company research, were reported at the 25th Anniversary meeting of the Petroleum Division of the American Chemical Society, in Chicago, Sept. 10 and 11.

Much of the data reported, either in its present form or after further development work, will be capable of application to improve such commercial refining operations as gasoline sweetening, catalytic cracking and others. Some of this research work is the result of wartime projects and is now for the first time made public. Important research work reported by the Petroleum Division included:

Gasoline Sweetening:—New technique for regenerating caustic treating solutions by air blowing in the presence of regeneration catalysts, such as tannin.

Catalytic Cracking:—Development of the theory that reactions of hydrocarbons with solid catalysts occur as a result of the exchange of energy between the hydrocarbon and catalyst atoms.

An experimental method for testing catalyst activity and its application to Fluid catalytic cracking operations.

Studies of the properties of naphthas from Fluid catalytic cracking.

A method for the control of reactions in heat transfer salt systems in the Houdry process to prevent the raising of the freezing points of the system beyond practical limits, or the formation of insoluble materials which settle out in the systems.

Aviation Gasoline: — Use of simple hydrogenation to reduce the unsaturation of catalytically cracked aviation gasoline to improve the stability and lean mixture octane number of the product.

Chemical Refining of Aromatics:—Wartime methods developed for treating toluene from petroleum to secure the necessary degree of purity can be applied to refining other aromatics for solvent and chemical applications.

Lubricants:—Viscosity index improver additives can be made more effective by the addition of chemicals which control the solubility of the improver polymer in the base oil in relation to the temperature.

Laboratory Procedure: — Improved type of glass bubble plate column, providing high throughput in the analytical distillation of hydrocarbon mixtures. Brief reviews of some of these developments follow:

Use of Tannins as Oxidation Catalysts In Regenerating Treating Solutions

The use of tannins and allied chemicals as mercaptan oxidation catalysts, soluble in alkaline treating reagents, was described as offering an economical means for regenerating solutions used in the removal of mercaptans from gasoline, in a report presented by the Technical Service Division of Socony-Vacuum Oil Co., Inc.

The report was prepared three years ago but its disclosures were held up by the wartime secrecy restrictions. At present Socony-Vacuum Oil Co. is affiliated with Shell Oil Co. in the promotion of the process. It has already been installed in some new commercial plants and it was said that existing doctor or mercaptan removal treating plants can be easily converted to the new type of operation. Data contained in the report will be of value in the consideration of a commercial regeneration operation.

"It has been known for some time," the report states, "that caustic solutions containing mercaptides could be externally, or internally, regenerated by reaction with oxygen to form disulfides. The rate of this reaction under normal conditions, however, is too slow for practical use. Some investigators advocated the use of insoluble metal salts for catalyzing this reaction but none of the catalysts found commercial use.

"A study was undertaken to ascertain how the rate of this reaction could be more effectively catalyzed. It has been found from this work that a number of groups of compounds are capable of promoting a rapid, economical regeneration of treating solutions containing mercaptans by air blowing at atmospheric temperatures. Disulphides formed by oxidation of mercaptans, are insoluble in the treating solution and may be separated by simple settling or other suitable means.

"Those types of catalysts which have been found most effective for regeneration of treating solutions thus far are: Tannic acid or tannins, phenolic acids and polyhydroxybenzenes. All of these catalysts are soluble in the treating solution, insoluble in the gasoline and relatively stable under the conditions of extraction and regeneration." On the basis of the experimental work it was believed that tannins are the best catalyst for general use.

In order to prevent the oxidation of the tannin catalyst during regeneration it was found necessary to keep a definite minimum amount of mercaptan in the solution to act as an oxidation inhibitor.

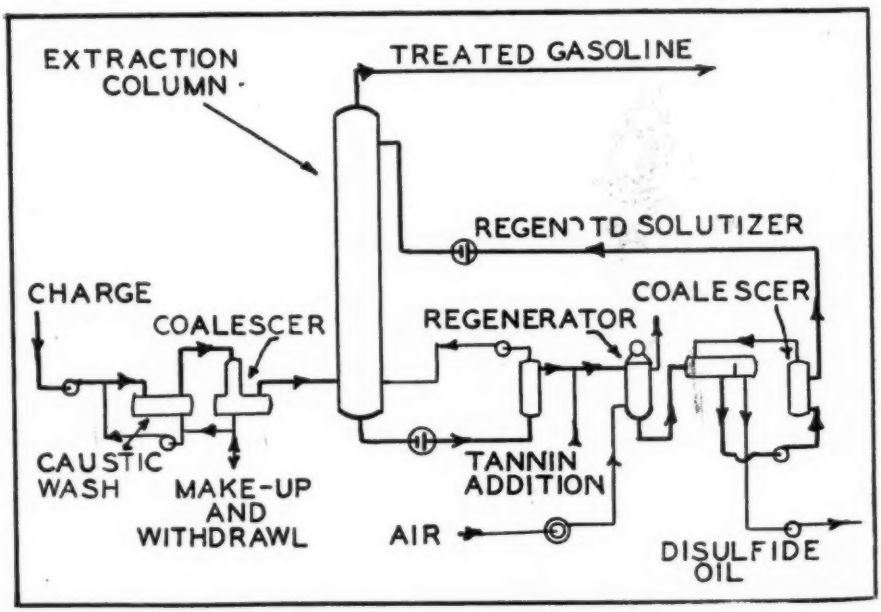


Fig. 1—Tannin Solutizer process (Flow digram courtesy Foster Wheeler Corp.)

Experiments were performed to determine the approximate concentration of mercaptan sulfur to protect the catalyst and the results are reported in the paper.

In addition to their use as catalysts in the oxidation of mercaptans to disulphides the tannins were said to also exhibit some mercaptan solubility promoting effects. This feature was said to be of interest in treating gasolines containing small amounts of heavy mercaptans which do not require the use of special "solutizing" treating solutions.

The report stated that the method of gasoline treating, using chestnut tannin extracts as an oxidation catalyst, had been in full scale operation at a Socony-Vacuum refinery for 7 months treating 1000 b/d of a motor gasoline from Talco crude containing 0.60% to 0.75% mercaptan sulfur. The mercaptan sulfur of the treated gasoline varied from 0.001 to 0.003% and the operation was described as satisfactory in every respect.

The air requirement was from 2.5 to 3 times the theoretical and it was found necessary to add during the 7 months' period only 480 lbs. or 8.7% of the initial charge of chestnut extract. The reduction in the total sulfur content of the gasoline during treating corresponded to the decrease in the mercaptan sulfur content obtained. Other plants were to be converted to this method of operation for treating motor gasolines.

Advantages of regeneration of treating solutions by air blowing in the presence of catalysts such as tannins were given as:

"Cost of regeneration, through use of air, is very low.

"Existing doctor or mercaptan removal treating plants may be easily converted to this type of operation.

"Low temperature regeneration allows use of ordinary steel and keeps corrosion at a minimum.

"Lower mercaptan sulfur contents of treating solutions, possible through use of a catalyst, allows greater use of less efficient 'solutizer' type solutions. Lower viscosities of these weaker solutions decreased emulsion and gasoline loss problem.

"Elimination of odor nuisance, since disulphides are formed as a by-product."

The report on the use of tannins in mercaptan removal treating was prepared by John Happel and S. P. Cauley, Technical Service Division, Socony-Vacuum Oil Co. Following its presentation, a Shell Oil Co. representative described the process which this company has installed in several new plants for various refiners.

Dr. Gustav Egloff, newly elected chairman of the ACS Petroleum Division. Dr. Egloff is Director of Research for Universal Oil Products Co., immediate past president of the American Institute of Chemists, and has been voted "one of the 1000 leading men of science" by the American Academy of Arts and Sciences.

New Theory of Mechanism of Solid Cracking Catalysts is Presented

Work done at the Socony-Vacuum laboratory at Paulsboro, N. J., on solid catalysts through a study of butane with the aid of tracer materials was reported by R. C. Hansford, technologist of that company, in a paper entitled "A Mechanism of Catalytic Cracking." The theory was developed that many reactions proceed through the exchange of proton atom particles between the catalyst and the hydrocarbon undergoing reaction. The experimental work was concerned chiefly with the part played by silica-alumina catalysts in the direct catalytic conversion of butane and the catalytic "reforming" of the products of the accompanying thermal cracking.

The marked influence of relatively small amounts of adsorbed water on cracking activity suggested some interaction of the water with the adsorbed hydrocarbon undergoing catalysis. This was proved by adsorbing deuterium oxide in place of normal water in the catalyst pre-conditioning treatment and carrying out cracking experiments with n-butane. Mass spectrometer analysis showed extensive deuterium exchange in the cracked products as well as in the unconverted butane. A blank non-catalytic experiment with a mixture of hydrocarbon and deuterium oxide failed to show any deuterium exchange in any of the products.

Since all known effective solid catalysts contain one or more hydrous metallic oxides it has been suggested that water in some way plays an important part in this type of catalysis. Just how water enters into the catalysis by silica-alumina or other metallic oxide combinations is not at all clear, the report brings out. It is believed, however, that the chemical nature of silica-alumina surfaces appears to hold the key to the puzzle, rather than the physical structure. The report refers to a recently presented "unitary theory of catalytic hydrocarbon reactions" based on a hydrogen donor-acceptor mechanism. This theory was applied to acid catalysts of the sulfuric and phosphoric type, the application to silica-alumina catalysts being very obscure.

Silicic acid and aluminum hydroxide are both recognized as very weak acids because of the high residual bonding strength of oxygen for hydrogen. The report continues on this point, "Now if this residual bonding power of oxygen be weakened by sharing with another atom, e.g., coordination aluminum of the OH oxygen in silica-alumina, the result is a much stronger acid because of the dissociability of hydrogen.

"Hydrogen exchanged or activated clays have been recognized by many investigators to have relatively strong acid characteristics. In a qualitative way, at least, it can be shown by indicators that the 'surface pH' of a silica-alumina gel prepared at pH = 7 is several units lower than that of a pure silica gel prepared at the same pH.

"Water adsorbed on the surface of a silica-alumina gel may be pictured as following the Bronsted concept as a base (proton acceptor) and the hydroxyl group at the surface as an acid (proton donor). Part of the adsorbed water hydrates the available protons from the catalyst and part is adsorbed in an activated state capable of acting as a strong base to accept protons from adsorbed hydrocarbons.

"Alternatively, there appears to be no reason why the hydrated proton (hydronium ion) could not be a proton acceptor itself, but it should be less of a base than water, since it was formed from water and a proton. At high temperatures, however, this may not be the case. In any event water is involved as a proton acceptor, taking protons either from the —OH groups or from hydrocarbons under the proper conditions.

"The proton accepting mechanism is applicable principally to paraffin or cy-

cloparaffin reactions. There seems to be no reasonable mechanism whereby a paraffin could take a proton from the catalyst . . . The only reasonable possibility is for the catalyst-water system to take a proton from the paraffin, giving a negatively charged molecule which can rearrange, decompose, or combine with a positive fragment or particle."

Deuterium exchange experiments with paraffins and cycloparaffins show that fairly high temperatures are required to activate proton removal. On the other hand exchange occurs with olefins and aromatics at much lower temperatures. Proton donations by the catalyst is the important mechanism involved with these hydrocarbons, it was pointed out.

"Many other reactions, such as polymerization, hydrogen transfer, cyclization, etc., may be pictured to proceed through the ions formed as a result of proton exchange between the catalyst and hydrocarbon," the report concludes. The formation of isoparaffins from higher paraffins or olefins probably occurs through intraionic rearrangement followed by splitting to an isoparaffin and hydrogen deficient fragment (intra-molecular hydrogen exchange).

Test Unit for the Study Of Catalysts During Use

A small laboratory scale test to evaluate quickly the quality of catalysts in use in actual plant operations was developed at the Esso Laboratories of the Standard Oil Co. of New Jersey (Louisiana Division) at Baton Rouge. Work along this line was described in a paper entitled, "Testing of Cracking Catalysts" by M. E. Conn and G. C. Connolly. The former is at the Baton Rouge laboratory, the latter at the Esso Laboratories of Standard Oil Development Co. at Elizabeth, N. J.

A test unit of the fixed-bed type was designed, constructed and operated to test simultaneously four small samples of catalyst (generally 200 cc,) in four KA$_2$S (18-8 Cr-Ni steel) tubes supported in an electrically heated aluminum-bronze block. During the development of the Fluid process and the operation of commercial units, catalyst samples are removed from time to time and tested in the 200 cc. test units to determine their quality.

Other such units have since been constructed and are employed for studying a wide variety of reactions and for investigating feed stocks and operating variables as well as catalysts. A total of more than 11,000 test runs have been made on these units at the Baton Rouge laboratories, it was reported.

Samples from Fluid units are usually taken from near the bottom of the regenerated catalyst standpipes. They are compressed into $\frac{1}{16}$ in. long by $\frac{1}{8}$ in. diameter cylindrical pellets. Nearly all samples are pretreated by calcining at 850-900° F. Application of the test data to fluid operations is discussed briefly.

Studies were also made at the Esso Laboratories at Baton Rouge of the composition of more than 100 naphthas representing a wide variety of conditions encountered in Fluid cracking operations. The conditions comprised operating temperatures of 750-1000° F., feed stock conversions of 35-90%, use of both clay and synthetic catalysts, and the processing of low and high-boiling naphthenic-type and paraffinic-type feed stocks. Special methods of analysis were developed and an original graph scheme for plotting the naphtha compositions. The conclusion of the report on this work states:

"The salient compositional features of Fluid catalyst cracked light naphthas comprise the olefin content and the concentrations of toluene and the C$_8$ aromatics. High octane numbers are favored by a composition such that the fractions of 200-300° F. boiling range contain toluene plus C$_8$ aromatics in a concentration on the order of 50 to 80 vol. %. Olefin contents of the fractions below 200° F. boiling point may vary over the range of 10 to 60 vol. %, requiring selections in regard to finishing treatment and use, since olefins are desirable in motor fuels but are objectionable in aviation fuels.

"Naphthas from naphthenic-type feed stocks are characterized by high yields on feed together with high aromatics concentrations, reflecting higher yields of toluene and C$_8$ aromatics than are obtained by cracking paraffinic type feed stocks under comparable conditions. Yields of naphthenes and cyclo-olefins tend to be higher in naphthas from naphthenic feed stocks, but yields of the C$_4$-C$_5$ paraffins and olefins are reduced."

The cracked naphthas obtained from the Fluid process are sources for a number of valuable hydrocarbons or groups of hydrocarbons that are useful as raw materials for chemical manufacture or for production of high quality polymers, alkylates and solvents. The report on properties of naphthas from Fluid catalyst cracking was prepared by C. E. Starr, Jr., J. A. Tilton, and W. G. Hockberger of the Esso Baton Rouge laboratories.

Cary Wagner, re-elected secretary-treasurer of the ACS Petroleum Division, has served as its chairman and has long been active in the Society. Associated with Pure Oil for almost 20 years and chief chemist since 1930, he is now a consulting chemist with offices in Bartlesville, Okla.

Control of Reactions In Houdry Salt System

Phase relationships in Houdry heat transfer salt systems were reported as resulting from a survey made as an aid to the detection, evaluation and control of certain chemical reactions normally taking place which, if allowed to continue, ultimately affect the utility of the systems. It was pointed out that at present a total of 30,000,000 pounds of heat transfer liquid is now employed for temperature control in Houdry fixed-bed catalytic cracking units.

The liquid used for this purpose is a eutectic mixture of molten potassium nitrate and sodium nitrate. This mixture was chosen because of its high heat capacity (approximately 0.35 BTU/lb./° F.), its low melting point (285° F.), its negligible corrosion on ordinary carbon steel at temperatures up to approximately 1000° F., and its low cost (6-8c/lb.).

The chemical properties of the mixture and the design of the equipment in which it is used are such that it is extremely stable at its normal operating temperature in Houdry units, i.e. between 800° and 900° F. The salt systems are designed to prevent, within practical limits, contact between air or other gases and the molten salt. However, under operating conditions certain chemical reactions normally take place slowly which, if continued, raise the freezing points beyond practical limits or form insoluble materials which settle out in the systems.

The chemical reactions which are described as taking place in the salt systems are oxidation of nitrite, formation of hydroxide ion, and formation of carbonate ion. Methods for the commercial control of these reactions are given. The paper on this subject was prepared by J. Alexander Jr., and S. G. Hindin, of Houdry Process Corp.

Solubility Reducers Used With VI Improvers

It is generally known that certain high molecular weight polymers, such as polybutylene, can be added in small amounts to lubricating oils to improve their Viscosity Index. Work has been done in the laboratories of Stanco Distributors, Inc.

AEROLUBE*

Dithiophosphate Additives for Better Lubricating Oils

✓ **Unexcelled Oxidation Inhibition**

✓ **Unexcelled Corrosion Inhibition**

✓ **Maximum Engine Cleanliness**

When Performance Counts . . . Call on Cyanamid

*Reg. U. S. Pat. Off.

AMERICAN Cyanamid COMPANY

Industrial Chemicals Division

PETROLEUM CHEMICALS DEPARTMENT

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

N. P. N.

American Cyanamid Company
Petroleum Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.

Gentlemen:
Please send me a copy of your new bulletin "AEROLUBE Additives For Lubricating Oils."

Name_____

Position_____

Company_____

Address_____ State_____

City_____

of Standard Oil Co. of New Jersey, to explain why the ability to improve the VI is limited to polymers having definite solubility characteristics.

In the report presented at the ACS Petroleum Division meeting, data was given to show that the VI of polymer-oil blends can be greatly enhanced by adding as a third component certain synthetic chemicals or oils which serve to reduce the solubility relationship between oil and polymer. Three-component systems of this type were said to produce oils of abnormally high VI.

As a result of work done in a study of effect of temperature on the viscosity of high molecular weight polybutylene in pure solvents, the view was expressed that the polymer existed in the oil blend in two phases—a molecularly dispersed polymer in solvent phase and a mechanically dispersed solvent in polymer phase within the first phase.

"During the period of maximum thickening power, the polymer molecules are distended and completely dispersed in the oil," the paper on this subject stated. "As the concentration of polymer in oil increases in a poor solvent, the thickening power becomes less."

It is indicated, the report goes on, that the solubility characteristics of polymer and solvent are important to the resulting viscosity-temperature relationship of polymer blends. It is necessary, therefore, that any polymer capable of improving the viscosity index of an oil must pass through this reduced solubility transition at the temperature of measurement, e.g., within the range of 100-210° F. It must show reduced viscosity improving effect at 100° F. and act normally at 210° F.

"We conclude, therefore," states the report, "that a polymer capable of improving the VI of an oil must undergo a period of less to more solubility in an oil between the temperatures at which the slope of the viscosity-temperature curve is determined, e.g., 100° F. and 210° F., such a change in solvation being a function of the structure or the molecular weight of the polymer and affecting the relative viscosity increasing power of the polymer at the two temperatures."

This paper entitled "Polymers and Viscosity Index," by H. C. Evans, Stanco Distributors Inc., and D. W. Young, Standard Oil Co. of New Jersey, was the result of work completed in 1943 to develop improved oils for heavy duty service and has only recently been released for publication.

High-Throughput Laboratory Distillation Apparatus

An improved glass bubble plate column providing "reasonably good" analytical distillation results at a high rate of throughput has been devised by the Emeryville, Cal., laboratories of Shell Development Co. It is illustrated in Fig. 2. This apparatus and its use was described in a paper entitled "Evaluation of Laboratory Distillation Apparatus," by Frank C. Collins and Vernon Lantz, both of Shell Development Co.

Preliminary comparisons on various types of laboratory distillation columns indicated that the Oldershaw glass bubble plate column has exceptional high throughput capacity and a low operating hold-up per theoretical plate relative to other columns, stated the report.

"These facts, together with the fact that the fractionating efficiency of the column is nearly independent of the throughput rate and shows no significant variation with time or from column to column, makes the bubble plate column an excellent tool for analytical distillations, especially in commercial laboratories where high fractionating efficiency for a given length of column is a secondary consideration compared with the reproducibility of results and length of distillation time.

"The bubble plate column as originally described by Oldershaw has been improved by making the plates more uniform and by increasing the number of holes per plate, thus materially increasing the throughput capacity of the column. Auxiliary equipment, such as automatic stillheads, timers, and product receivers, has been developed which has contributed to the reproducibility of the data obtained with the glass bubble plate column." A maximum feed rate in excess of 4000 ml/hour is ordinarily considered satisfactory for this type of column.

The work at Emeryville also included developing test methods for evaluating laboratory distillation apparatus under conditions approximating actual operation rather than under ideal conditions for maximum separation. A series of test methods was devised for measuring the principal variables affecting column operation under conditions approximating actual operation. In particular, test procedures were devised for evaluating column efficiency at finite reflux ratios, for measuring feed rates to the column, operating hold-up, static hold-up, heat loss, pressure drop and the actual reflux ratios provided by automatic still heads.

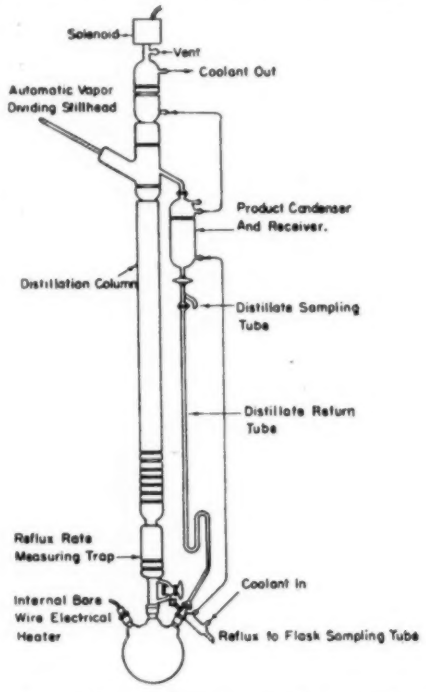


Fig. 2—An improved glass bubble plate distillation column and accessories arranged for fractionating efficiency tests

Miscellaneous

One paper presented before the Petroleum Division summarized experimental work carried out at the Pan American Refining Corp. plant at Texas City, Texas, during the war in connection with the refining of nitration grade toluene produced by hydroforming petroleum naphthas. The paper consolidated reports previously supplied to the Army Ordnance Department and the Toluene Technical Committee, and it points to possible wider application of the method for treatment of toluene in the field of chemical refining of aromatic hydrocarbons.

In the wartime investigation, the work with specific hydrocarbons showed that the presence of diolefins in toluene is harmful in the acid wash color test even at concentrations as low as 0.00 to 0.01%. Reactions with maleic anhydride confirmed these conclusions. A toluene treating process using 0.005 to 0.01% maleic anhydride has been shown to produce toluene of exceptional acid wash color.

Vapor phase treating with UOP polymerization catalyst has been demonstrated to be an effective method of toluene treating. Data was also given on the variables in conventional sulfuric acid treating and on accelerated test methods to compare the efficiency of different treating conditions and to predict the acid wash color stability of the product.

This work was covered in a paper entitled, "The Chemical Refining of Aromatic Hydrocarbons from Petroleum," by P. L. Brandt, R. J. Lee, F. T. Wadsworth, all of Pan American Refining Corp., Texas City.

A paper prepared by the National Bureau of Standards described the purification and determination of freezing points and purity of an additional 29 hydrocarbon compounds, under the cooperative program on standard samples of hydrocarbons of the Bureau and the American Petroleum Institute. The 29 compounds included 8 nonanes, 6 alkylcyclohexanes, 11 alkylcyclopentanes and 4 butylbenzenes. A previous report gave similar data for 36 compounds.

Another report, also prepared by the Bureau of Standards, described the procedure and apparatus used in the purification and sealing "in vacuum" of 19 standard samples of hydocarbons which are available for test work.

Exclusive PETROLEUM PROCESSING Series for Use in Precise Design and Operation of Fractionating Equipment

The function of distillation in petroleum refining is so basic and well established it is taken for granted that design engineers and refinery operators are entirely familiar with the principles of physical chemistry involved. However, new methods have come into use and the distilling of petroleum mixtures in general is far more complex than even a few years ago. For the precise operations required today, a more extensive knowledge of the fundamental conception of fractional distillation is required, as well as an understanding of the special processes being applied, such as azeotropic and extractive distillation, for example. To meet this need the editors of PETROLEUM PROCESSING have arranged for an exclusive series by a recognized research authority in Chemical Engineering.

FRACTIONAL DISTILLATION

By ROBERT R. WHITE
Associate Professor, Dept. of Chemical and Metallurgical Engineering, University of Michigan

Article 1—Fundamental Principles of Equilibrium Distillation Explained; Graphical Methods Given for Calculating Basic Material and Energy Balances Required in Design of Columns

Introduction

The development of the petroleum industry has been more or less concurrent with the evolution of the art and science of distillation. While it is difficult to determine which is cause and which is effect, it is certain that the modern petroleum refinery is bound inextricably to distillation operations in the many separations which are necessary.

In the early days of refining, product specifications were easy to meet and only rough separations of the crude material were required. With the advent of thermal cracking and the processing of natural gas to recover gasoline, pressure distillation and more careful control of the gasoline vapor pressure became necessary, thereby stimulating interest by necessity in the more precise design of fractionating equipment.

At present, the petroleum industry is producing and processing nearly pure compounds isolated from crude oil by extensive and precisely controlled distillation operations. In addition, the increasing interest of petroleum refiners in the chemical field is requiring the application of special distillation processes known as azeotropic or extractive distillation.

The basic function of distillation in refining oil makes it imperative that refinery personnel be familiar with the fundamentals of distillation. For those directly concerned with process and equipment design an even more extensive knowledge is required. It is the purpose of this series of articles to present a comprehensive review of the aspects of distillation which are important in refining operations. The material presented will begin with very simple operations and will attempt to carry the reader up to modern methods for designing columns for distilling complex petroleum mixtures. In order to bring out clearly the elementary principles the first articles will deal with the fractionation of binary mixtures. Later articles will discuss ternary and multi-component mixtures which form more or less ideal mixtures. The design and operation of azeotropic and extractive columns will be considered as well as other operations.

Classification of Distillation Problems

Distillation has been defined as the separation of the constituents of a liquid mixture by partial vaporization of the mixture and the separate recovery of vapor and the liquid residue. In such an operation, the more volatile components of the original mixture, i.e., those having the higher vapor pressure, are usually obtained in increased concentration in the vapor, while the less volatile components are obtained in increased concentration in the liquid residue. This phenomenon is the basis of all distillation operations.

The study of distillation is concerned with three main considerations; (1) the effect of operating variables on the concentrations of various components in the vapors and liquids, (2) the expenditure and transfer of energy required to produce the phases, and (3) the design of the equipment in which the operations are conducted.

The concentrations of the various components in the liquid and vapor streams depend fundamentally on the rates at which material is transferred between the phases. Two methods are generally used in handling the problems of rates. One involves the assumption of equilibrium conditions and the correction of the results obtained by this assumption to actual conditions by the use of "efficiencies" evaluated from actual performance data. The other method deals with the rates of transfer from a more fundamental point of view and involves the direct application of mass transfer theory.

The first method has by far the widest application because of its simplicity and the fact that a large proportion of distillation equipment approaches rather closely the equilibrium stage. However, in distillation equipment such as the packed tower, the direct application of mass transfer theory has given promising results.

The expenditure and transfer of energy required in distillation operations is primarily a thermodynamic problem which is relatively easy to solve within the limits of the fundamental data available.

The design of the equipment required is probably the most important, since errors made in estimating the compositions of the various streams or in the amounts of energy can usually be corrected by adjusting operating conditions. On the other hand errors in the physical construction of the equipment are more or less permanent and are likely to limit its capacity and flexibility. The main problems of design are concerned with the contact produced between the phases and particularly with the capacity of the equipment with respect to liquid and vapor flow.

Binary Mixtures

Equilibrium distillation, which may be defined as that operation in which all of the vapors generated are in equilibrium with all of the liquids throughout the course of the distillation, is the simplest illustration of the physical chemistry underlying

distillation operations. While an equilibrium distillaton may be conducted either at constant temperature or at constant pressure, constant pressure distillation is more important commercially.

The temperature-composition diagram of benzene-toluene at one atmosphere pressure, a typical binary ideal mixture, is shown in Fig. 1.

The point *A* in Fig. 1 represents a mixture at a temperature such that it is entirely liquid. As this liquid is heated at constant pressure, its path may be represented by the vertical line *AH*, since the composition will remain unchanged. When the liquid reaches the point *C* on the saturated liquid line, it will be at its bubble point and any further increase in temperature will produce vaporization. The composition of the first bubble of vapor produced will correspond to the point *D* on the vapor saturation line.

Since this vapor is in equilibrium with the remaining liquid, it must also be at the same temperature, so that, in general, the composition of co-existing equilibrium liquid and vapor phases may be determined from the intersection of horizontal lines of constant temperature with the saturated liquid and vapor lines.

At the point *C*, there is an infinitesimal quantity of vapor, *D*, in equilibrium with the liquid *C*. As the temperature of the mixture is increased to the point *E*, the quantity of vapor has increased and its composition is now given by the point *G*, the composition of the remaining liquid being given by the point *F*. The mol fraction of the total mixture which is liquid is equal to the relative distance *EG/FG*. Similarly the mol fraction which is vapor is equal to the relative distance *EF/FG*.

As the temperature of the mixture is increased to the point *I* on the vapor saturation line, the quantity of liquid becomes infinitesimal, its composition being designated by the point *J*. Upon a further increase in temperature the liquid-vapor interface disappears and the mixture, a vapor having the same composition as the liquid of *A*, is represented by the point *H*.

The operation of increasing the temperature of the mixture where there are two phases present in equilibrium at constant pressure constitutes an equilibrium distillation. The reverse operation of cooling a vapor mixture through the two phase region is an equilibrium condensation.

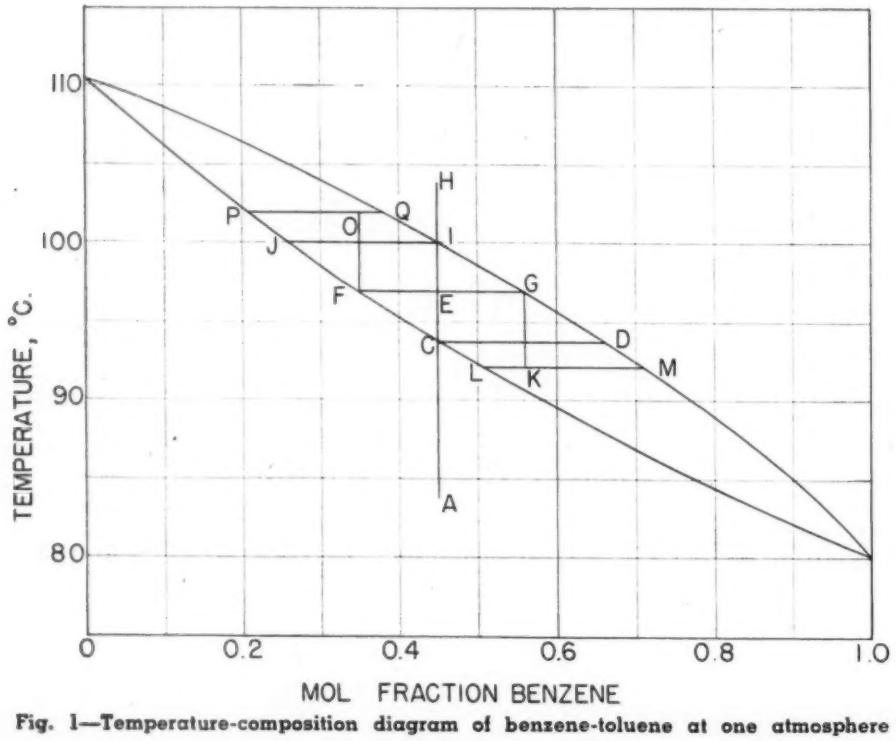


Fig. 1—Temperature-composition diagram of benzene-toluene at one atmosphere pressure

Meet the Author

R. R. White

Robert R. White received his B.S. degree in Chemical Engineering from the Cooper Union Institute of Technology in 1936 and his M.S. and Ph.D degrees from the University of Michigan in 1938 and '40.

After obtaining his Bachelor's degree, he worked for the Calco Chemical Co. as a junior chemist and chemical engineer. During post-graduate studies at Michigan he worked on special research for Dow Chemical Co. He was later employed in the Research and Development Department of Standard Oil Co. of California and in the Legal Department of Universal Oil Products Co.

He is a co-recipient of the Junior Award of the American Institute of Chemical Engineers for 1945 and the Russell Award of the University of Michigan for 1945. He is now associate professor in the Department of Chemical and Metallurgical Engineering, University of Michigan.

The complete vaporization of the mixture from the point *C* to the point I produces no separation of the components of the mixture because only one phase results from this operation. On the other hand, the partial vaporization of the mixture produces two phases which differ in composition, the vapor phase containing a higher concentration of the more volatile component and the liquid phase containing a higher concentration of the less volatite component. If these two phases were separated, a partial separation of the components of the original mixture would be effected.

A combination of the two processes, equilibrium distillation and condensation, may be used to increase the extent of separation of the original mixture. Thus the mixture at the conditions represented by the point *A* could be heated to the temperature point *E*, and the phases represented by the points *F* and *G*, separated. The vapor *G* could then be partially cooled to the point *K*, at which temperature two phases would develop, represented by the points *L* and *M*. Similarly the liquid *F* could be heated to the point *O*, at which temperature the two phases resulting are represented by the points *P* and *Q*.

The net result of this operation is to provide a further separation of the original mixture over that obtained by merely heating to the point *E*. By repeating this operation, that is, partially condensing the vapors, partially vaporizing the liquids, and combining intermediate fractions to be subjected again to the same treatment, it is possible to approach a complete separation of the original mixture into its pure components. This method was used in the ancient past to accomplish separations but is very laborious and un-

economical for commercial use because of the large number of operations involved and particularly the large amount of heat required to conduct the many vaporizations.

The processes just described have been batch operations. The same considerations, however, apply to continuous equilibrium distillation such as is shown in Fig. 2(B) where a feed is introduced continuously to a vessel fitted with a heating coil through which heat may be supplied to the liquid in the vessel. The vapors generated are withdrawn continuously through the top vapor line and the remaining liquids are withdrawn continuously through the bottom draw-off line.

The relative quantities and the compositions of the streams leaving the vessel depend upon the temperature and pressure maintained in the vessel. The temperature, quantities and composition of the exit stream may be calculated by material and energy balances, if the pressure, the composition and temperature of the entering stream, and the heat added are known. These calculations require a knowledge of the enthalpy-composition relationships for the system involved, as well as equilibrium data such as those shown in Fig. 1. The enthalpy relationships for binary systems are conveniently shown on the enthalpy-composition diagram such as that shown in Fig. 3.

Enthalpy-Composition Diagrams

An enthalpy-composition diagram shows the relative enthalpy of mixtures as a function of composition along lines of constant temperature. In many cases, the chart is limited to a single pressure, but different pressures may be included if desired. The enthalpy may be expressed in any convenient unit such as BTU's per pound or BTU's per pound mole. Where the enthalpy is plotted in BTU's per pound, the composition is given in weight fraction units and where the enthalpy is given in BTU's per pound mole, the composition is given in mole fraction units.

Fig. 3 shows the enthalpy composition diagram for the system ethanol-water at one atmosphere pressure. The reference states of relative enthalpy for this chart are pure water at 32° F., and pure ethanol at 32° F. The line labeled 150° shows the enthalpies of various liquid mixtures of ethanol and water at a temperature of 150° F. Similar lines are plotted for other temperatures.

The solid line labeled, "saturated liquid," shows the enthalpies of liquid mixtures of ethanol and water at their saturation temperature corresponding to one atmosphere pressure, that is, at their atmospheric bubble point. The solid line labeled, "saturated vapor," shows the enthalpies of vapor mixtures at their saturation temperatures corresponding to

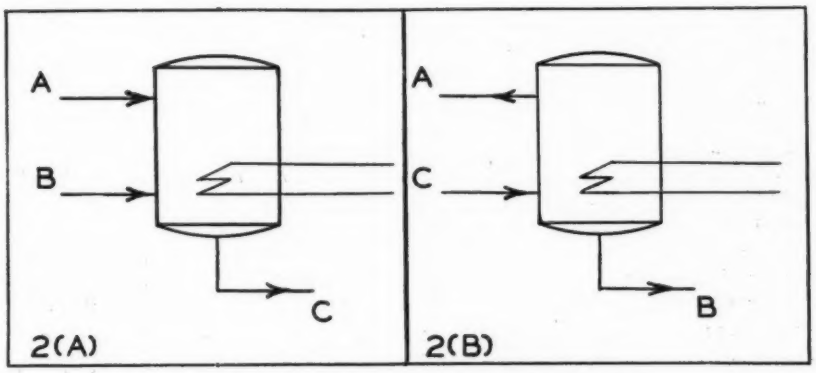


Fig. 2—Continuous equilibrium distillation

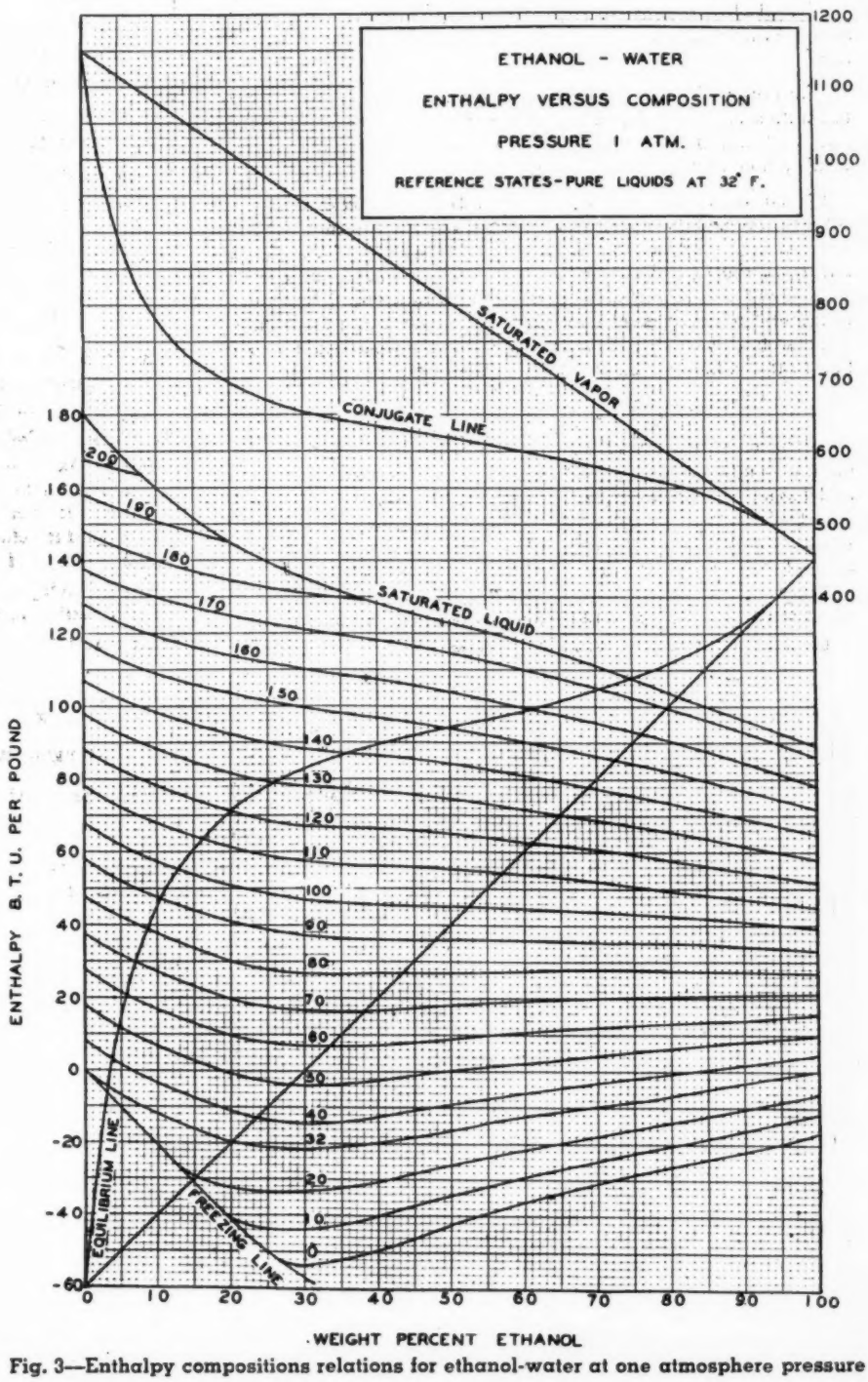


Fig. 3—Enthalpy compositions relations for ethanol-water at one atmosphere pressure

one atmosphere pressure, that is, at their atmospheric dew point.

A line connecting a liquid composition on the saturated liquid line, with the equilibrium vapor composition on the saturated vapor line, is known as an equilibrium tie line. There are an infinite number of tie lines which connect all points on the saturated liquid line with the corresponding equilibrium vapor compositions on the saturated vapor line. An equilibrium tie line on the enthalpy-composition diagram corresponds to a horizontal temperature line on a temperature-composition plot such as the line *FG* shown in Fig. 1.

The equilibrium compositions which determine the terminal points of a tie line may be represented by the so-called "*x-y*" diagram, which is superimposed on the enthalpy-composition diagram of Fig. 3 labeled, "equilibrium line." This line shows the relation between the weight per cent of ethanol in the liquid, *x*, plotted along the abscissa and the weight per cent of ethanol in the equilibrium vapor, *y*, plotted along the ordinate to the right.

The points along the equilibrium line are located by plotting the intersection of the horizontal temperature line with the saturated liquid and saturated vapor lines of a temperature-composition plot such as Fig. 1.

For convenience in translating the relationship shown by the equilibrium line to equilibrium tie lines on the enthalpy-composition chart, at 45° line is included. In order to locate a tie line from the equilibrium line, the *y* value corresponding to a given *x* value is projected from the equilibrium line horizontally to the 45° line and thence vertically to the saturated vapor line. The tie line is drawn from this point on the saturated vapor line to the value of *x* on the saturated liquid line.

Material and Energy Balances

In the operation shown in Fig. 2(A) streams *A* and *B*, containing weight fractions x_a and x_b of the more volatile component, and having enthalpies H_a and B_b, BTU per pound, flow into a vessel where they are mixed continuously. Stream *C*, containing weight fraction x_c of the more volatile component, and having an enthalpy H_c, BTU per pound, is withdrawn so that steady flow conditions exist. The quantities flowing per unit time of the three streams are *A*, *B*, and *C* pounds per hour respectively.

By a material balance around the vessel,

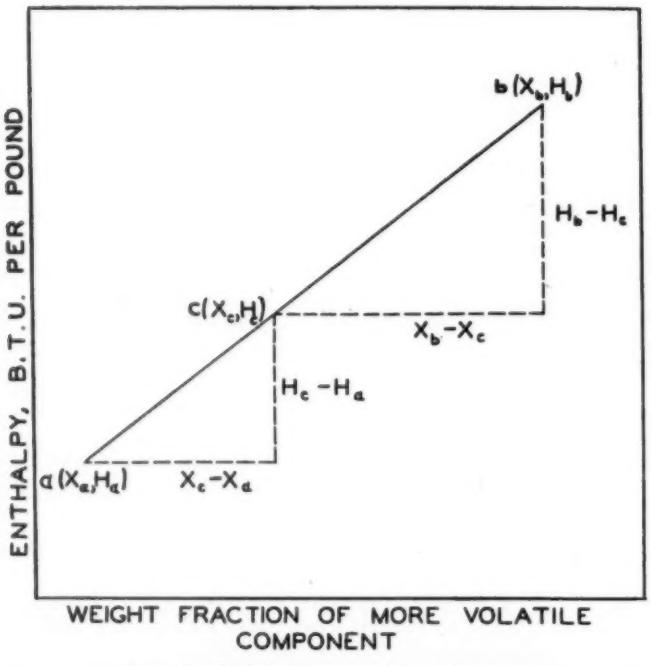


Fig. 4—Enthalpy-composition diagram

Coming Articles
in Series on Fractional Distillation

New petroleum problems will be emphasized and illustrated with numerous examples, and quantitative application of fundamental theory will be stressed in this series on Fractional Distillation by Dr. White. One article will appear in each issue for eight consecutive months. The outline follows:

1. Fundamental Concepts of Fractional Distillation.
2. Calculation of Plate Columns for Binary Distillation.
3 & 4. Complex Binary Operations and Special Methods, Parts I & II.
5 & 6. Bubble Plate Column Design, Parts I & II.
7. Distillation of Multicomponent, Mixtures, Ternary Distillation.
8. Light Hydrocarbon Distillation.
9. Crude Oil Distillation.
10. Azeotropic and Extractive Distillation.

$$A + B = C \quad \ldots\ldots (1)$$

and by a more volatile component balance,

$$Ax_a + Bx_b = Cx_c \quad \ldots\ldots (2)$$

By an energy balance under steady flow conditions,

$$\Delta H + \Delta x + \Delta u^2/2g = q - w \quad \ldots\ldots (3)$$

If there is no heat transfer to or from the fluids in the vessel, $q = 0$. If there is no shaft work done on or by the fluids $w = 0$, and if velocity and gravitational effects may be neglected, $\Delta u^2/2g = 0$, and $\Delta x = 0$. Therefore, $\Delta H = 0$ and

$$CH_c - AH_a - BH_b = 0 \quad \ldots\ldots (4)$$

By substituting the value of *C*, given by Equation 1 in Equations 2 and 4.

$$\frac{A}{B} = \frac{x_c - x_b}{x_a - x_c} = \frac{H_c - H_b}{H_a - H_c} \quad \ldots\ldots (5)$$

and rearranging Equation 5

$$\frac{H_b - H_c}{x_b - x_c} = \frac{H_c - H_a}{x_c - x_a} \quad \ldots\ldots (6)$$

The points *a*, *b*, and *c*, representing the enthalpies and compositions of streams *A*, *B*, and *C*, are plotted on an enthalpy-composition diagram in Fig. 4. The term $(H_b - H_c)$ of Equation 6 is represented by the vertical distance from point *b* to point *c*. The term $(x_b - x_c)$ is represented by the horizontal distance from point *b* to point *c*. The term $(H_b - H_c)/(x_b - x_c)$ is the slope of the straight line connecting points *b* and *c*.

By Equation 6 this slope is equal to the slope of the straight line connecting points *c* and *a*, and since both lines pass through the point *c*, the three points *a*, *b*, and *c* define one straight line. The ratio of distances between the three points *a*, *b*, and *c* are equal to the ratio of the quantities of the three streams *A*, *B*, and *C*. By Equation 5,

$$\frac{A}{B} = \frac{bc}{ac}; \quad \frac{A}{C} = \frac{bc}{ab}; \quad \frac{B}{C} = \frac{ac}{ab} \quad \ldots\ldots (5a)$$

The straight line, *abc*, of Fig. 4 is the graphical solution of the energy and material balances expressed by Equations 1, 2, and 4, and can be used instead of the equations for any purpose.

If the quantities, compositions, and enthalpies of streams *A* and *B* are known, the enthalpy and composition of stream *C*

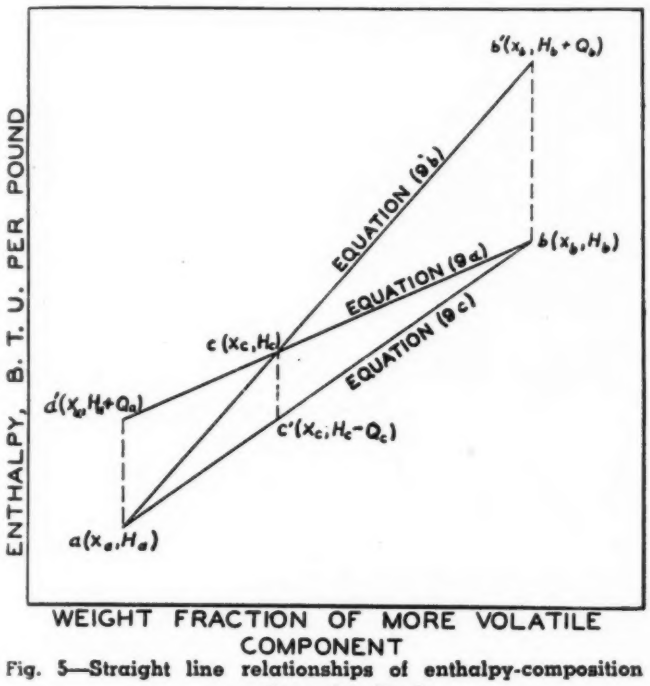


Fig. 5—Straight line relationships of enthalpy-composition equations, 9a, 9b, 9c

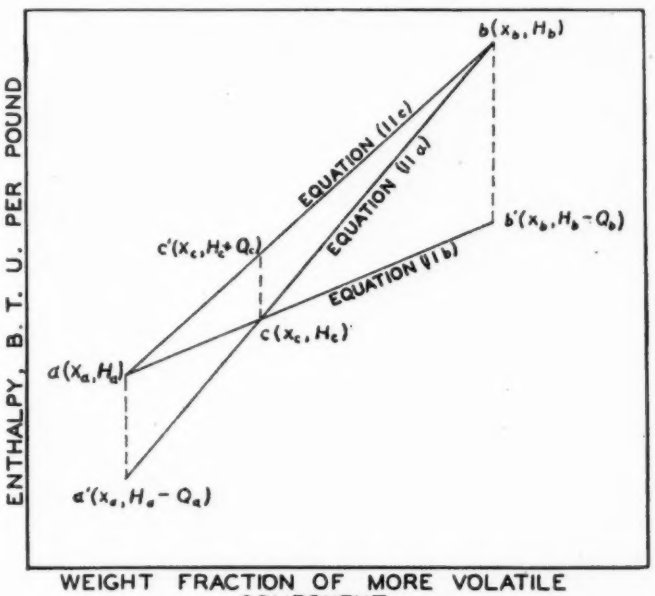


Fig. 6—Straight line relationships or enthalpy-composition equations 11a, 11b, 11c

can be calculated from Equations 1, 2, and 4, or can be determined graphically by locating the point c on the straight line ab of Fig. 4, so that the ratio of the distances, bc/ac, is equal to the ratio A/B of the feed streams. Similarly, if the enthalpies, and compositions of streams A and B are known and either the enthalpy or composition of stream C is known, the other property of stream C may be read directly from the straight line ab and the quantities of the three streams may be determined by evaluating the ratios of the distances as indicated by Equation 5a.

When two streams, A and B are added, the point c, representing the product stream C, will lie on the straight line ab and nearer to the stream present in the larger amount. In such cases, the point c might be called an "addition point."

The point, c, represents the sum of streams A and B flowing into the vessel of Fig. 2(A) or into any vessel, even though a stream C is not produced. If the streams A and B were processed in a vessel to produce three dissimilar streams, D, E, and F, under steady flow conditions, the point, c would represent not only the sum of streams A and B flowing into the vessel, but also the sum of the streams, D, E, and F, leaving the vessel.

In the continuous process shown in Fig. 2(B), stream C is being separated into two dissimilar streams A and B under steady flow conditions. The process may be considered as the separation of stream C to produce streams A and B, or, as the subtraition of stream A from stream C to produce stream B, or, as the subtraction of stream B from stream C to produce stream A. In any case, the process is identical to the addition of streams A and B to produce stream C (Fig. 2(A) except for the reversal of the directions of flow, and the relations expressed by Equations 1 through 6 apply. Therefore, the same straight-line relationship on the enthalpy-composition diagram is applicable, and Fig. 4 represents the subtraction of stream A from stream C the relative quantities of the three streams.

When one stream, A, is subtracted from another, C, the point b, representing the properties of the resulting stream, B, lies on the extension of the straight line through points a and c (never between them). In such cases, the point b might be called a "difference point," and it will lie nearer the point representing the stream present in the greater amount.

If the quantity of stream A is equal to the quantity of stream C, the difference point b, lies at an infinite distance from point c, in order that the ratio of the distances $bc/ab = A/C = 1.0$ (Equation 5a). Obviously, a stream B obtained by subtracting stream A from stream C cannot have a weight fraction of more volatile component greater than 1.0 or less than 0.0. Thus, there is a definite limit to the amount of stream A which can be subtracted from stream C to produce a stream B having real properties.

However, the point b may represent the difference between A and C even though the stream B is not actually produced. Where stream B is not actually produced, the difference point, b, need not represent the properties of a real stream. For example, in the calculation of multiple-feed columns, the point representing the difference between the vapor passing upward, and the liquid flowing downward through the section between the feed plates, often has a composition coordinate of less than 0.0 or greater than 1.0 on the enthalpy-composition diagram.

Heat Transfer under Steady Flow Conditions

If heat is transferred to the fluids flowing through the mixing vessel shown in Fig. 2(A), q is no longer zero and Equation 4 becomes

$$CH_c - AH_a - BH_b = q \quad \ldots\ldots (7)$$

The quantity of heat transferred to the system (the fluids in flow) may be expressed as a function of the quantity of any one of the streams, or

$$q = AQ_a = BQ_b = CQ_c \quad \ldots\ldots (8)$$

The equation of the straight line representing the operation on the enthalpy-composition diagram takes one of the following forms, depending upon how the quantity of heat transferred is expressed.

$$\frac{(H_a + Q_a) - H_c}{x_a - x_c} = \frac{H_c - H_b}{x_c - x_b} \quad \ldots\ldots (9a)$$

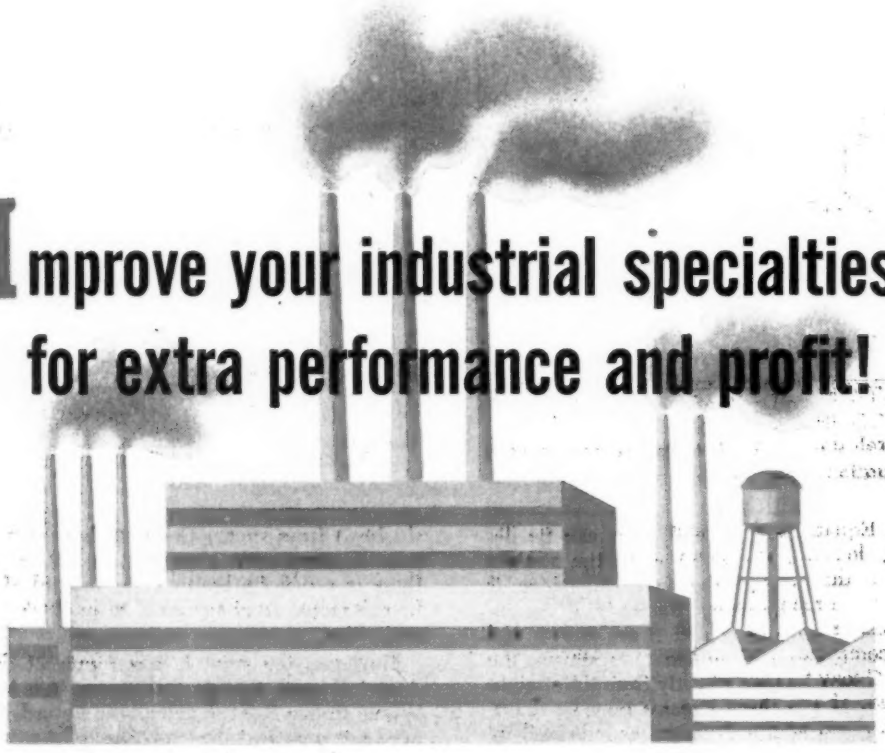
$$\frac{H_a - H_c}{x_a - x_c} = \frac{H_c - (H_b + Q_b)}{x_c - x_b} \quad \ldots\ldots (9b)$$

$$\frac{H_a - (H_c - Q_c)}{x_a - x_c} = \frac{(H_c - Q_c) - H_b}{x_c - x_b} \quad \ldots\ldots (9c)$$

The relationships expressed by Equations 9a, 9b, and 9c are plotted in Fig. 5.

The point b' $(x_b, H_b + Q_b)$ now represents the subtraction

Improve your industrial specialties for extra performance and profit!



Build your industrial oils and specialties with PARAMINS—Paranox 441 and 447-A inhibitors . . . Paratac for oils and greases that "stay put" . . . Vistone B for oiliness and wear protection.

PARAMINS* make good oils and greases better!

ADDITIVES WITH A BACKGROUND

PARAMINS INCLUDE:
PARATONE —*for improved viscosity index.*
PARAFLOW—*for lower stable pour.*
PARATAC —*for tacky oils and greases.*
PARAPOID —*for E.P. gear oils.*
PARANOX —*for inhibiting corrosion and oxidation.*
PARASHEEN—*for better appearance.*
PARADYNE —*for improved gasoline.*

*Trade Mark

Distributed by: Stanco Distributors, Inc., 26 Broadway, New York 4, N. Y.; Stanco Distributors, Inc., 221 North La Salle St., Chicago 1, Ill.; The Carter Oil Co., P. O. Box 801, Tulsa, Okla.; Griffin Chemical Co., Los Angeles and San Francisco, Calif.; Imperial Oil Ltd., 56 Church St., Toronto 1, Canada

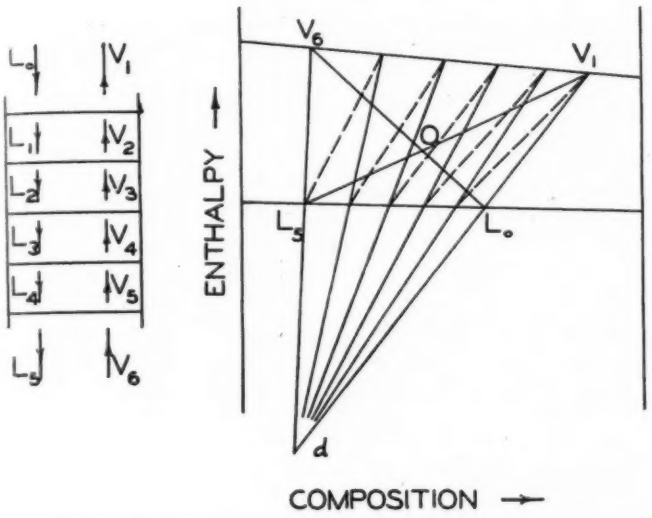


Fig. 8—Enthalpy-composition diagram for several equilibrium plates

of stream A from stream C to produce the stream B plus the energy added to the process per pound of B, and the straight line passes through points a and c, representing streams A and C, as q has been included in b'. Similarly, the point a' (x_a, $H_a + Q_a$) represents the subtraction of stream B from stream C to produce A plus the energy added to the process per pound of A. The point c' (x_c, $H_c - Q_c$) represents the addition of streams A and B to produce stream C less the energy added to the process per pound of C.

If heat is transferred to the system shown in Fig. 2(B) Equation 4 becomes

$$AH_a + BH_b - CH_c = q \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

and depending upon how q is expressed (Equation 8), the equation of the straight line representing the operation will take *one* of the following forms:

$$\frac{(H_a - Q_a) - H_c}{x_a - x_c} = \frac{H_c - H_b}{x_c - x_b} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11a)$$

$$\frac{H_a - H_c}{x_a - x_c} = \frac{H_c - (H_b - Q_b)}{x_c - x_b} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11b)$$

$$\frac{H_a - (H_c + Q_c)}{x_a - x_c} = \frac{(H_c + Q_c) - H_b}{x_c - x_b} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11c)$$

The relationship expressed by Equations 11a, 11b, and 11c are plotted in Fig. 6.

The enthalpy coordinate of a point representing the combination of a given entering stream and the energy added to the process is determined by adding the energy per pound of the entering stream to its enthalpy. If the given stream is leaving the process, the energy added to the process per pound of effluent stream is subtracted from its enthalpy.

If enthalpy-composition diagrams are not available, they can be constructed from thermodynamic data. If justified by the type of mixture involved, the assumption of ideal solutions may be used as a basis for constructing the diagrams from the properties of the pure components. This procedure is applicable to a wide variety of hydrocarbon mixtures provided the pressure is well below the critical region of the mixture.

Equilibrium Stage Calculations

Consider now the equilibrium stage shown in Fig. 7 corresponding to one idealized plate of a plate fractionating column. The saturated liquid L_0, and the saturated vapor, V_2 are fed continuously to this stage where they are intimately mixed. The mixed phases separate into the vapor V_1 and the liquid L_1 which

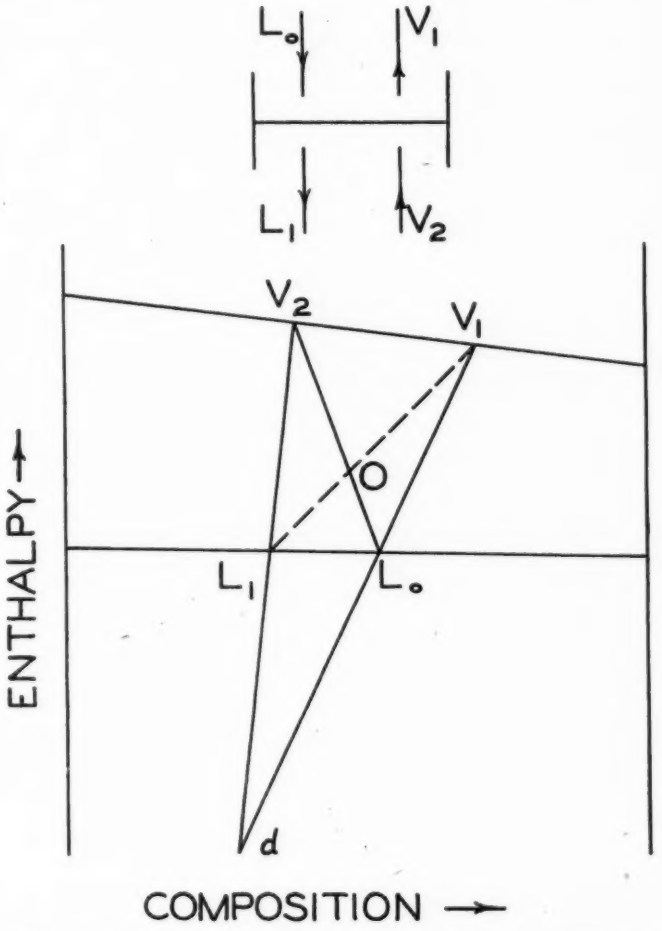


Fig. 7—Enthalpy-composition diagram for one equilibrium plate

leave the stage and which, by definition, are in equilibrium. This operation is represented by the enthalpy-composition diagram shown in Fig. 7. The point V_2 represents a saturated vapor feed to the stage and therefore lies on the vapor saturation line; the point L_0 represents a saturated liquid and lies on the liquid saturation line.

The point O represents the sum of the liquid and vapor feed to the stage and is located on the straight line V_2L_0 so that the ratio of the distances OV_2/OL_0 equals the ratio of the quantities of the feed streams, L_0/V_2. The sum of the liquid and vapor feeds to the stage must equal the sum of the equilibrium liquid and vapor leaving the stage, and therefore the vapor, V_1, and the liquid, L_1 are represented by the terminal points of the equilibrium tie line which passes through the point O. The fractionation accomplished by the stage may be expressed either as the change in vapor composition produced, $y_1 - y_2$, or as the change in liquid composition, $x_0 - x_1$. It is clear that both a liquid and a vapor stream must be fed to the stage in order to produce the fractionation.

The difference between the liquid L_0 and the vapor V_1 passing one another above the stage is equal to the difference between the liquid L_1 and the vapor V_2, passing one another below the stage. This difference is represented by the point, d, which is located by the intersection of the line L_1/V_2 and L_0/V_1. The quantity ratios L_1/V_2 and L_0/V_1 are equal to the distance ratios dV_2/dL_1, and dV_1/dL_0 respectively.

Several Equilibrium Plates

A system of plates placed one above another, such as is shown in Fig. 8, constitutes a plate column.

The point L_0 represents a saturated liquid feed to the top plate, and the point V_6 represents a saturated vapor fed under the bot-

tom plate of the column. The sum of the feed streams, L_0 and V_6, is represented by the point O, so located on the straight line L_0V_6 that the ratio of the distances, OV_6/OL_0, equals the ratio of the feed quantities, L_0/V_6. Since the sum of the feed streams equals the sum of the product streams, L_5 and V_1, the point O is also located on the straight line L_5V_1 and the ratio of the distance OV_1/OL_5 equals L_5/V_1.

The difference between the liquid feed, L_0, and the vapor product, V_1, which pass one another above the top plate, equals the difference between the vapor feed, V_6, and the liquid product, L_5, which pass one another below the bottom plate. The point d, which represents this difference, is located at the intersection of the lines L_0V_1 and L_5V_6.

The difference between the liquid and vapor passing one another above the top plate and below the bottom plate is also equal to the difference between the liquid and vapor passing one another between any two plates of the column, i.e., between V_2 and L_1, V_3 and L_2, V_4 and L_3, etc. The point, d, is therefore the common point of intersection for the straight lines drawn through all of the pairs of points representing the liquid and vapor passing one another between any two stages of the column.

The liquid L_1 leaving the top plate is in equilibrium with the vapor V_1 leaving the top plate and the point L_1 in Fig. 8 is located at the end of the equilibrium tie line from the point V_1 on the vapor saturation line, representing the vapor product. The point, V_2, representing the vapor rising from the second plate and passing the liquid L_1, is located at the intersection of the line dL_1 with the vapor saturation line. The liquid, L_2, leaving the second plate is in equilibrium with the vapor, V_2, leaving the second plate, and is represented by the point L_2, located at the end of the tie line from the point V_2. The point V_3, representing the vapor rising from the third plate is located at the intersection of the line dL_2 with the vapor saturation line. The plate to plate construction is carried out in this manner until a liquid composition is obtained which is equal to that of the bottom product.

In Fig. 8, the tie line L_5V_5 terminates exactly at the point L_5 which was located by the overall material and energy balances around the column. This is entirely fortuitous and in most cases the end of the tie line will not terminate at exactly the bottom product composition. This means that it is impossible to obtain the separation specified with an integral number of plates and, while the tie line could be made to terminate exactly at the point L_5, determined from the material balance by adjusting the ratio of the feeds slightly, it is pointless to do so, since the number of actual plates required is determined by dividing the number of theoretical plates by a plate efficiency. Therefore, as a general rule, the plate-to-plate construction is continued until a liquid composition is obtained which is less than that of the bottom product composition and the fractional plate estimated by a linear interpolation along the liquid saturation line.

NEW BOOKS FOR THE REFINER

Tentative Specifications and Tests For LPG Published by C.N.G.A.

Tentative Specifications and Tentative Standard Methods of Test for Liquefied Petroleum Gases, Bulletin TS-441, California Natural Gasoline Association, 8½ x 11 in., looseleaf, heavy paper cover, $1.00 to members, $1.50 to non-members.

Tentative Specifications and Tentative Standard Methods of Test for Liquefied Petroleum Gases sets up six standard grades of LPG, classified by vapor pressure and gravity, each having a wide allowable range in composition. The range in maximum vapor pressure at 100° F. goes from 80 psig to 200 psig, and the gravity, 60° F./60° F., from 0.585-0.555 to 0.520-0.504. The high gravity, low v.p. gases are predominantly butanes; the low gravity, higher v.p. are chiefly propanes, and the range between is varying mixtures of the two.

Methods of test are given for vapor pressure, specific gravity, weathering residue, isobutane content of propane, water content. In addition, supplementary graphs, tables, and charts are provided, as well as diagrammatic sketches of testing apparatus.

The specifications and test methods as incorporated in the booklet were accepted by the Executive Committee of the CNGA, November 14, 1944.

Correction

The Modern Plastics Encyclopedia, reviewed in the August 7, 1946, issue of National Petroleum News, Technical Section, was listed at a price of $5.00. The correct price is $6.00 in the United States.

Scientific Instruments Explained By Fifteen British Specialists

Scientific Instruments, 1946, edited by Herbert J. Cooper, 5¾ x 8¾ in., 305 pages, stiff cloth binding, illustrated, indexed, $6.00.

Scientific Instruments discusses a wide range of physical measuring instruments. Not only laboratory instruments but also those used in the field, in industry, and in commerce are well covered. In addition to descriptions, much space is devoted to a discussion of principles and to methods of measurement.

Complete with diagrams and photographs, the book is divided into five sections of broad types of instruments and each chapter contains a section on various specific classes. Of interest to the petroleum man will be those chapters devoted to various types of spectroscopes (X-Ray and Mass-spectrographs); refractometers; fluid pressure, temperature, time speed, and density measuring devices; and viscosimeters.

Other instruments covered include all types of optical devices, navigational and surveying, calculating machines, vacuum tubes and thermionic valves. Fifteen specialists and many large companies and organizations (British) have contributed to this comprehensive volume.

The editor, Herbert J. Cooper, is Head of the Engineering Department, South-West Essex Technical College and School of Art, England.

Petroleum Developments Review In 1945 A.I.M.E. Transactions

Petroleum Development and Technology, 1945, Transactions of the American Institute of Mining and Metallurgical Engineers, Petroleum Division 6¼ x 9¼ in., 666 pages, stiff cloth binding, illustrated, indexed.

Petroleum Development and Technology includes papers and discussions presented before the AIME Petroleum Division at meetings in Los Angeles, October, 1943 and October, 1944; Houston, May, 1944; New York, February, 1944; and one meeting scheduled but canceled for New York, February, 1945; also the statistical reports covering the year 1944.

The bulk of the material covered is on production; Chapter I on Production Engineering and Research consists of 15 papers. Chapter II, Petroleum Economics, includes three pages.

Summary reports on production in the various producing states in this country as well as foreign producing nations are given in Chapter III. A review of petroleum engineering education, and one of refinery engineering complete the volume. Numerous tables and maps are given in the section devoted to summary reports.

Copies of all books reviewed on this page can be ordered from the Book Department of PETROLEUM PROCESSING, 1213 West Third St., Cleveland, 13, for the prices listed, postpaid. Ohio purchasers please add 3% tax.

PERSONALS

Petroleum Technologists in the Headlines

Mr. Hanneken

Mr. McConnell

George W. Hanneken has retired as vice president in charge of manufacturing for the Standard Oil Co. (Ohio) and was succeeded on Sept. 1 by **Elliott B. McConnell.**

Mr. McConnell, the new manufacturing head was born in Oil City, Pa. He entered the engineering school of Cornell University in 1919 and graduated with a B.S. in Chemistry.

After graduation he became associated with the Standard Oil Co., of New Jersey where he took a six months refinery training course, and was assigned to the cracking coil technical service and development department division. He later became process inspector of tube and tank units acting as a clearing house on new developments in the process and recommending operating improvements.

He joined Sohio in 1928 when the company started new cracking operations. The following year he was made assistant to the vice president in charge of manufacture and in 1945 was made general manager of the manufacturing department.

Mr. McConnell is credited with 15 patents in the petroleum field.

* * *

C. A. Pollard is the new assistant general manager of Standard of California's Richmond refinery. He joined the Company in 1921 and has been at the Richmond refinery for the past 16 years. He was the manager of the refining divisions. **C. W. Rehfuss,** manager of service division at Richmond, takes over Mr. Pollard's former duties. Mr. Rehfuss has been with the company for 22 years.

* * *

Dr. P. C. White has been promoted to chief chemist at Standard of Indiana's Whiting refinery, succeeding **Dr. F. M. Rogers** who retired Sept. 1. Dr. White joined the company in 1938 after receiving his Ph. D from Chicago University. In 1945 he was made chief assistant chemist.

* * *

J. P. Allen, technical assistant in charge of the catalytic cracking plant of the Baltimore, Md., refinery of Standard Oil Co., (N. J), has been promoted to general foreman of the cracking department, and **William Muly** has been named unit foreman of the catalytic cracking and light-ends units. Other promotions include **Gilbert E. Filler,** appointed unit foreman of the thermal cracking and naphtha rerun unit and **Herbert E. Wilhem,** named a general foreman. **William J. Sheridan,** process control engineer, has been appointed assistant head of the technical department at Baltimore.

* * *

William B. Stevens, formerly process products engineer for the New York City division of Socony-Vacuum Oil Co.., has been made staff engineer in the process products division of that company.

* * *

Lawrence J. Grunder is back with Richfield Oil Corp., at Los Angeles, after four years with the Army on various fronts in Europe. He is now chief products research engineer in the Products Research Development Department of Richfield. This is similar to the work Mr. Grunder was doing prior to the war in 1942.

Mr. Grunder

As a Colonel in the Army Mr. Grunder was an automotive fuels and lubricants engineer and trouble shooter. He handled the fuels problems for the First Armored Division while they were quartered in Ireland and later was transferred to London to work with the Petroleum Section of the Ordnance Department. He was with Patton's Armies in North Africa and as the war progressed was with various outfits in Italy, Southern France, Rumania, Bulgaria and Greece. He was transferred to the Military Government when it moved into Austria.

Mr. Grunder was head of the Fuels and Mining Branch of the Economics Division for the U. S. Zone in Austria and was chairman of seven working committees.

He wears five battle stars, the Bronze Star and the Army Commendation ribbon. Mr. Grunder returned to this country in December of 1945.

* * *

Gavin R. Taylor, vice president in charge of the refining department of McColl-Frontenac Oil Co., Ltd., has been elected a director of the Company.

* * *

H. C. Rothe, manager of the engineering division of the Lubrite refinery of Socony-Vacuum Oil Co., Inc., at East St. Louis, Ill., has been transferred to the New York refinery engineering division.

The newly-formed California Refining Co., has named **Fred Powell,** manager of the refining division at Standard of California's El Segundo plant, president. Mr. Powell started to work for California Standard in 1925 in the company's Richmond refinery. He has also held posts at El Paso and Bakersfield refineries. The new corporation was organized under an agreement now awaiting approval by stockholders of the Barber Asphalt Co.

Mr. Powell

* * *

Dr. P. J. Merkus, Jr., until recently manager of research and development department, Shell Oil Co., Inc., New York, has been appointed assistant to the vice president in charge of manufacturing. Dr. Merkus succeeds H. D. Dale, who was appointed manager of the company's Wood River, Ill., refinery.

Dr. Merkus began with Shell in 1934.

F. C. Cutting, assistant manager of research and development department succeeds Dr. Merkus. He started with the company in 1925.

ADVERTISERS' INDEX

This index is published as a convenience to the reader. Every care is taken to make it accurate but Petroleum Processing *assumes no responsibility for errors or ommissions.*

Alcorn Combustion Co. 138
Aluminum Ore Co. 109
American Cyanamid Co. 149
Anderson Co., V. D. 105
Badger & Sons Co., E. B. 120, 121
Chicago Bridge & Iron Co. 117
Cooper-Bessemer Corp. ....Inside Front Cover
Du Pont de Nemours & Co., Inc. E. I. .. 123
Ethyl Corp. 82
Foster Wheeler Corp. .....Facing 96
Foxboro Co. 101
General Chemical Co., Baker & Adamson Division .....Inside Back Cover
Hammond Iron Works 131
Hooker Electrochemical 110
Houdry Process Corp. 91
Hudson Engineering Corp. 106, 107
Lummus Co. .....Facing 112
McKee & Co., Arthur G. 127
Metasap Chemical Co. 132
Monsanto Chemical Co. 115
Petroleum Processing 124, 143
Petroleum Rectifying Co. 145
Pritchard & Co., J. F. 141
Powell Co., Wm. 125
Stanco Distributors, Inc. (Paramins) 156
Universal Oil Products Co. 104
War Assets Corp. 133
Warren Petroleum Corp. 129
Wyatt Metal & Boiler Works ..... Outside Back Cover

WIDENING HORIZONS

Views on Personnel, Management and Economic as Well as Technological Developments in Petroleum Refining and Natural Gas Processing: Comment from Readers is Invited

Two-Plus-Two Can Be a "Fuzzy" Four In the ICCASP School of Thought

The Independent Citizens Committee for the Arts, Sciences and Professions (ICCASP) is appealing to the technologists of oil companies to join its ranks, as well as scientists of other industries, schools, research institutions and so on.

Following the well known technique of leftish, or communist-inspired organizations generally, it has seized on two important national issues, science legislation and atomic research, to announce itself as the champion of the interests of scientists in national affairs. Its position on these two important issues is not clearcut, which again is a leftish characteristic. However, the fact alone that ICCASP has taken up these issues has enlisted the support of many reputable scientists, who hope to secure through it the legislation they believe is needed on these issues.

Beyond the front of a few "big" names and the label it has given itself as the "non-partisan liberal and progressive group", not much is known about ICCASP; as to what role it really intends to play in national politics or international affairs, nor as to who actually is in control in the organization. These are points on which scientists, by nature of their training and their work, should particularly desire to inform themselves.

To give some light on the matter, the Chemical Bulletin of the Chicago Section of the American Chemical Society published in its September issue a debate on ICCASP. Both sides of the issue of support of this organization by scientists are given. The "Yes" side is presented by Malcolm Dole, a professor of Physical Chemistry at Northwestern University, chairman of the executive board of the Midwest Science Division of ICCASP. The "No" side is taken by Dr. Donalee L. Tabern, head of special research, Abbott Laboratories, Chicago.

The statements of both contain information which would seem to make ICCASP an organization whose policies and activities are completely at odds with the thinking of trained scientists, where freedom from dogma and independence of thought are a fundamental requisite to the successful pursuit of a profession. Here are some of the facts brought out:

The top personnel of ICCASP contains many individuals who are on record with past connections with communist front organizations it is pointed out by Dr. Tabern, and he gives official references. Of the 54 initiating sponsors, including many well known in the motion picture field, he says only two or three, "by the broadest stretch of the imagination," could be called scientists. Not one is a member of the American Chemical Society. According to the Congressional Record, 20 of the sponsors have been affiliated with from "two to 34 communist front organization."

Another evidence of the communist-like leadership of ICCASP is to be found in its methods of operating, says Dr. Tabern. Decisions are made at the top and are expected to be followed without question by the various sections and chapters and their membership. This includes not only policy matters but also support or opposition to pending legislation and of individual candidates for office. For example, the Wagner-Murray-Dingell socialized medicine bill, opposed by the great majority of physicians, and other scientists, is on the list of "must" legislation of ICCASP.

Chapters of ICCASP may endorse political candidates only with the approval of the national board of directors. The board, however, is empowered to "associate, affiliate, or make any other working arrangement with other working organizations having similar purposes" on any terms or conditions it deems advisable.

Professor Dole points out, in support of ICCASP, that it has been organized for the "avowed purpose of organizing political action among the professional people of America." The labor men have their unions, the manufacturers their NAM, he points out, but the professional people have never before united for political action. ICCASP has radio, actors', musicians' and artists' sections, as well as those for scientists. These types of "professional" people would greatly outnumber the scientists. They are also more adept at expressing themselves and in taking the spotlight of public attention than are the scientists.

In summation, the entire organization setup of ICCASP, its policies and its activities would seem to be repugnant to the scientist, whose instincts and training call for rigorous accuracy in statement and independence in thought.

Reprints of the complete article, "ICCASP?", from the Chemical Bulletin of the Chicago Section of the American Chemical Society can be had by readers by writing Editor, Petroleum Processing, 1213 W. Third St., Cleveland.

The West Coast Demonstrates Its Technological Achievements

A modern Horace Greeley could well admonish the young and ambitious engineers and technologists of this country to continue looking westward. The recent San Francisco Regional Meeting of the American Institute of Chemical Engineers demonstrated the importance of the industrial scientific work carried on on the West Coast.

It was brought out that the number of chemical engineers there has grown from about 500 to 2000 in 17 years and now represents 7.3% of the total number in this country.

The petroleum industry has been among the foremost of the groups expanding in the west. California alone today has nearly 18% of the refining capacity of the country, and is second only to Texas.

Another indication of the technological growth and enthusiasm of the west is its intense interest in whatever it does. It plays hard and it works hard. The San Francisco Regional Meeting committee expected about 350 engineers to attend the four-day session. Over 700 showed up. Attendance at the regular monthly meetings of the Los Angeles section of the American Chemical Society is over 300, while 100 is considered exceptional attendance in most eastern cities.

The west is young, and youth has vitality and strength and enthusiasm. It will continue to bring advances and improvements in the chemical industry in general and the petroleum processing industry in particular.

"RIGHT NEXT DOOR TO YOUR LABORATORY"

Extensive Stocks of **B&A Reagents and C. P. Acids** at your command from Coast to Coast*

To provide direct, personalized service for laboratory chemical users everywhere, the Baker & Adamson Division of General Chemical Company has its *own* chain of regional warehouses from coast to coast. Each is a strategic supply center carrying extensive stocks of B&A Reagents, C. P. acids, and other high purity B&A chemicals for prompt delivery.

One of these B&A regional warehouses serves your territory. By taking full advantage of its facilities, you can make it the auxiliary stockroom "right next door to your laboratory" that will eliminate your own stock control problem.

Here's how... advise your B&A Technical Serviceman as to your specific, month-to-month reagent requirements. This way, he can plan with you in building these local B&A stocks to furnish your needs swiftly, surely, whenever you call.

You can open the door to your B&A stockroom right now by phoning or writing the nearest B&A Sales and Technical Service Office listed below.

The free, 200-page book of B&A products is an excellent guide to the range of high-purity chemicals available from your regional B&A warehouse. It contains pertinent data on 1,000 products. If you have not yet received a copy, request one today on business letterhead.

REAGENTS
BAKER & ADAMSON B&A QUALITY
STANDARD OF PURITY
FINE CHEMICALS

GENERAL CHEMICAL COMPANY

BAKER & ADAMSON DIVISION

40 RECTOR STREET, NEW YORK 6, N. Y.

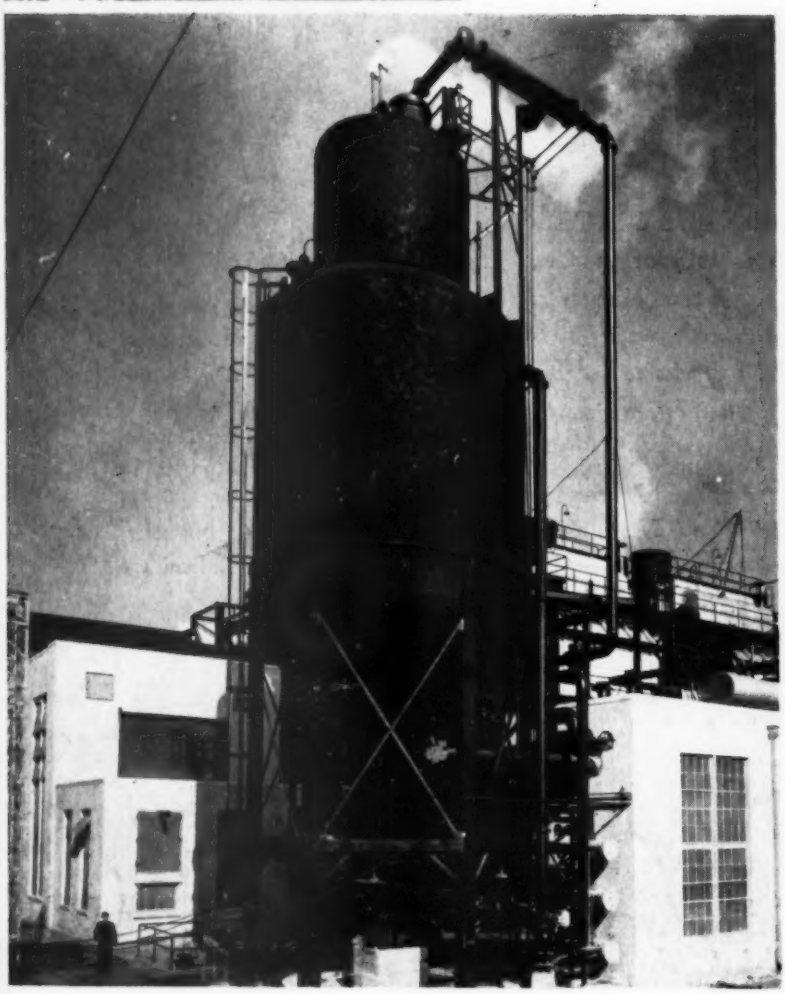
Sales and Technical Service Offices: Albany* • Atlanta • Baltimore • Birmingham* • Boston • Bridgeport Buffalo* • Charlotte* • Chicago* • Cleveland* • Denver • Detroit* • Houston • Kansas City Los Angeles* • Minneapolis • New York* • Philadelphia* • Pittsburgh* • Providence • St. Louis* San Francisco* • Seattle • Wenatchee (Wash.) • Yakima (Wash.)
In Wisconsin: General Chemical Wisconsin Corporation, Milwaukee, Wis.
In Canada: The Nichols Chemical Company, Limited • Montreal* • Toronto* • Vancouver

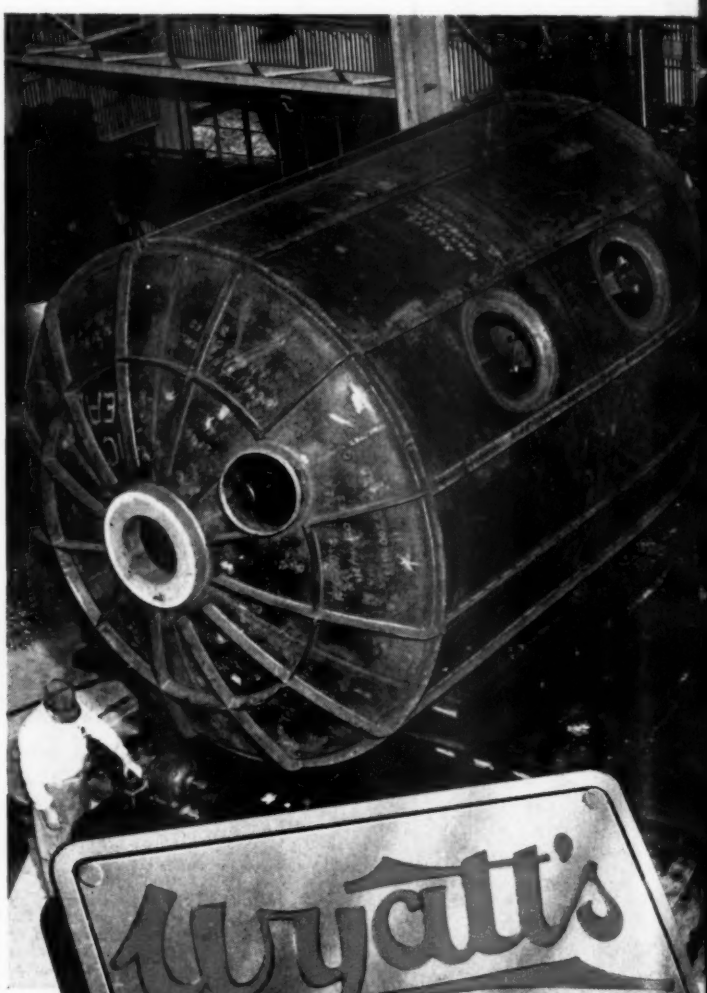
SETTING THE PACE IN CHEMICAL PURITY SINCE 1882

* Complete stocks carried here.

SPECIAL STEEL PLATE FABRICATING FOR MODERN INDUSTRY

Above: Aluminum tanks. Left: Buell van Tongeren catalyst collector. Lower left: Water softening equipment. Lower right: Rotating drum for rice processing.





Wyatt's

HOUSTON - DALLAS

WYATT METAL & BOILER WORKS

Steel plate designers, fabricators and erectors to industry's specifications